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REPORT #
RRTAC 92-3

Proceedings of the Industry/Government Pipeline Reclamation Success Measurement Workshop

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LAND CONSERVATION AND
RECLAMATION COUNCIL
Reclamation Research
Technical Advisory Committee

Alberta's Reclamation Research Program

Regulating surface disturbances in Alberta is the responsibility of the Land Conservation and Reclamation Council. The Council executive consists of a Chairman from Alberta Environment and two Deputy Chairmen from Alberta Forestry, Lands and Wildlife. The Council oversees a reclamation research program, established in 1978, to identify the most efficient methods for achieving acceptable reclamation in the province. Funding for the research program is provided by Alberta's Heritage Savings Trust Fund, Land Reclamation Program.

To assist with the development and administration of the research program, the Council appointed the inter-departmental Reclamation Research Technical Advisory Committee (RRTAC). The Committee consists of eight members representing the Alberta Departments of Agriculture, Energy, Forestry, Lands and Wildlife, and Environment, and the Alberta Research Council. The Committee updates research priorities, reviews research proposals, organizes workshops, and otherwise acts as the coordinating body for reclamation research in Alberta.

Additional information on the Reclamation Research Program may be obtained by contacting:

Chris Powter, Chairman
Reclamation Research Technical Advisory Committee
Alberta Environment
3rd Floor, Oxbridge Place
9820 - 106 Street
Edmonton, Alberta T5K 2J6
(403) 427-4147

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REPORT #
RRTAC 92-3

Proceedings of the Industry/Government

Pipeline Reclamation Success

Measurement Workshop

by

R.J. Mahnic, Communiplan Inc.

and

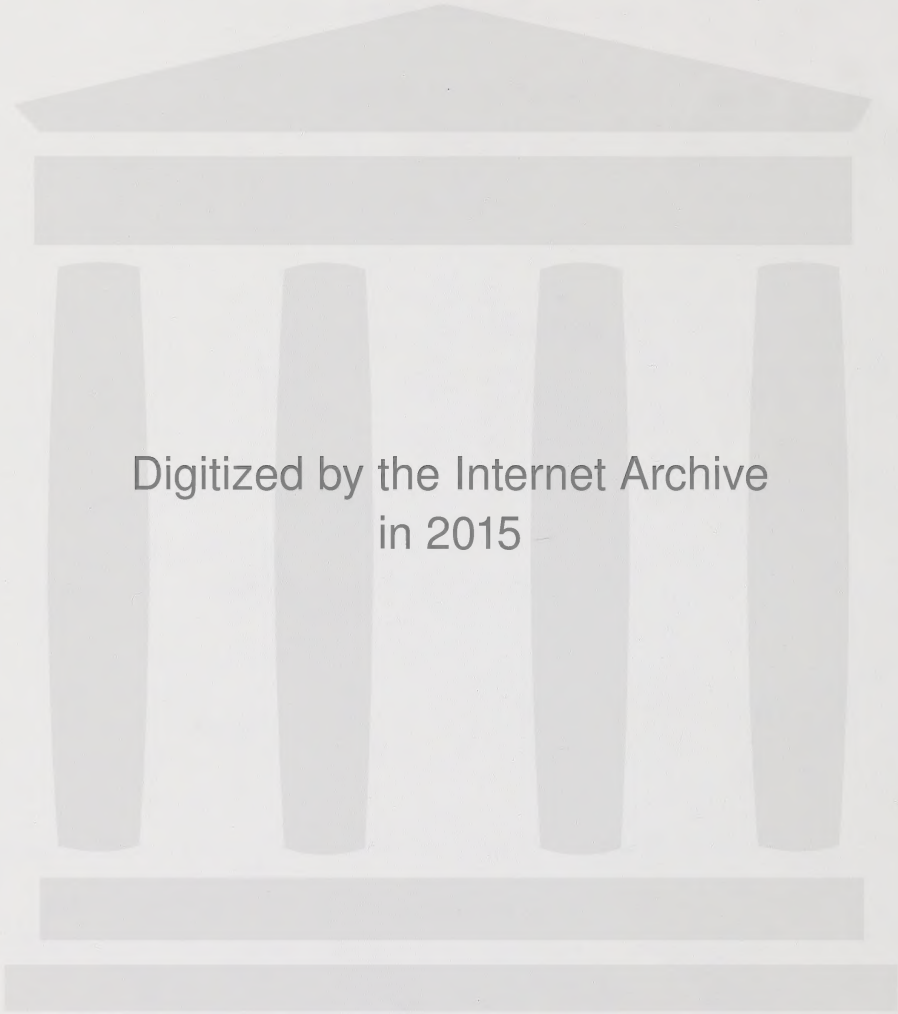
J.A. Toogood

Prepared for

Canadian Petroleum Association

and

The Oil and Gas Reclamation Research Program
ALBERTA LAND CONSERVATION AND RECLAMATION COUNCIL
(Reclamation Research Technical Advisory Committee)



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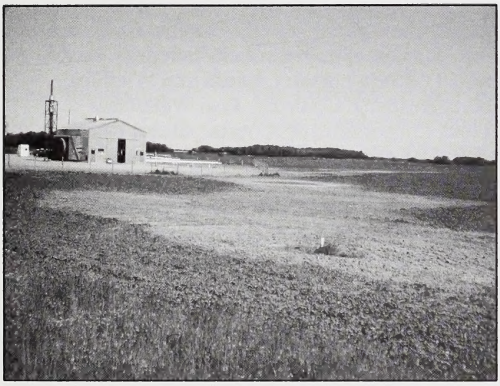

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DISCLAIMER

This report is intended to provide government and industry staff with up-to-date technical information to assist in the preparation and review of Development and Reclamation Approvals, and development of guidelines and operating procedures. This report is also available to the public so that interested individuals similarly have access to the most current information on land reclamation topics.

The opinions, findings, conclusions, and recommendations expressed in this report are those of the workshop participants and do not necessarily reflect the views of government or industry. Mention of trade names or commercial products does not constitute endorsement, or recommendation for use, by government or industry.

REVIEWS

This report was reviewed by members of the subcommittee of the Alberta Pipeline Environmental Steering Committee that was responsible for the workshop. Subcommittee members included: David Lloyd, Wayne Tedder, Dan Blackmore, and Adolf Bruneski (Alberta Forestry, Lands and Wildlife), Chris Powter (Alberta Environment), Terry Macyk (Alberta Research Council), Ivan Weleschuk (Energy Resources Conservation Board), Albert Lees (Nova Corporation of Alberta), Stuart Lunn (Pan Canadian Petroleum Ltd.), and Rob Durward (ENPRO Environmental Services Ltd.).

RRTAC especially wishes to thank Mr. David Lloyd, Alberta Forestry, Lands and Wildlife, Public Lands Division for chairing the subsommittee, and Mr. Ian Scott, Canadian Petroleum Association (now the Canadian Association of Petroleum Producers) for arranging the workshop facilities and coordinating industry participation.

FUNDING

Funding for this work was provided by the Alberta Heritage Savings Trust Fund, Land Reclamation Program through the Alberta Land Conservation and Reclamation Council. RRTAC thanks the Canadian Petroleum Association (now the Canadian Association of Petroleum Producers) for co-funding the project. The Association contracted David Walker and Len Knapik and paid for the workshop facilities.

GLOSSARY OF TERMS

The following terms are used in these proceedings.

Assessment	A judgement of the value or worth of something, either tangible or intangible.
Control Section	The vertical section of the soil upon which classification or evaluation is based. The depth will vary depending on the purpose or system being used.
D & R Plans	Refers to Development and Reclamation Plans.
EC	Refers to Electrical Conductivity, a measure of the soluble salt content of a soil.
Equivalent Land Capability	A situation where the ability of the land to support various land uses after reclamation is similar to the ability that existed prior to an activity being conducted on the land. The ability to support individual land uses will not necessarily be identical after reclamation.
Green Area	Refers to those public land areas of the Province of Alberta for which the Department of Forestry, Lands and Wildlife-Forest Services Division is responsible for management. These areas are predominantly unsettled, forested areas of the province.
Land	For the purposes of the definitions of land capability and equivalent land capability--land includes terrestrial, semi-aquatic, and aquatic landscapes.
Land Capability	The ability of the land to support a given land use on a sustained basis irrespective of future management inputs, activities or alterations. It refers to an evaluation or rating of the kind and degree of limitations on land use, in terms of physical, chemical and biological characteristics, such as topography, drainage, hydrology, soils and vegetation. It includes any existing abilities and conditions which are the result of previous alterations or management practices.
Measurement	Determining the magnitude, extent or degree of something.
Pedon	The smallest 3-dimensional unit in a landscape regarded as a soil.
pH	A symbol signifying the negative logarithm (base 10) of the hydrogen ion concentration of a solution or pure liquid expressed in gram equivalents per litre. The range of values of pH extends from 0 to 14. Lower numbers signify increasing acidity, higher ones increasing alkalinity.
Pipeline	Oil, gas and petroleum product gathering, transmission and distribution lines; and, special water lines for plant and enhanced recovery operations.
Pipeline Construction	Standard pipeline construction including: surveying, clearing, access, topsoil-handling, grading, trenching, blasting, pipe stringing, welding and weighting, pipe installation, drainage control, backfilling, clean-up, and reclamation.

Reclamation	The process of returning disturbed land to a useful and productive condition. Reclamation of pipeline rights-of-way is regulated under the Alberta Land Surface Conservation and Reclamation Act.
Right-of-way	The land over which a linear development, such as an oil or gas pipeline, passes. Through a legal instrument known as an easement, the company is granted the right to install, maintain, repair and replace a pipeline on the right-of-way. The easement spells out the rights of both the landowner and the company. Abbreviated as ROW.
Salinity	A measure of the amount of soluble salts in a soil.
SAR	Refers to Sodium Adsorption Ratio, which indicates the amount of exchangeable sodium in a soil relative to the amount of exchangeable calcium and magnesium.
Screening Assessments	An assessment which is intended to provide a relatively quick judgement of the reclamation situation on a pipeline right-of-way. It is essentially a quality control or conformance to standards procedure.
Sodicity	A measure of the amount of exchangeable sodium in a soil.
Soil Horizon	Layers in a typical mineral soil profile are often referred to as horizons. The major horizons are labelled A, B, and C, and there may be further subdivisions of these layers. The A horizon is found at the soil surface, contains the most organic matter, and is considered to be the layer with the best characteristics for plant growth. The A horizon is often called the topsoil. The B horizon occurs belows the A horizon and is usually intermediate in quality between A and C horizons. The C horizon is most similar to the underlying parent material and is, in some cases, composed of materials that are not suitable for plant growth.
Soil Mapping Delineation	Usually consist entirely of one soil series (Series A) or a grouping of two soil series (Series B and C) that realistically represent the true landscape.
Soil Profile	Consists of a vertical section of a soil through all its horizons and extending into the parent material.
Soil Series	Consists of groups of pedons, with the actual number of pedons being controlled by the range in defined limits of the particular series.
White Area	Refers to those public land areas of the Province of Alberta for which the Department of Forestry, Lands and Wildlife-Public Lands Division is responsible for management. These areas are predominantly settled, agricultural areas of the province.

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The invited technical presentations on soil and vegetation reclamation success were both in-depth and informative. We are most appreciative of the efforts of Mr. Len Knapik, Dr. Annabel Ness Evans and Dr. David Walker. Special thanks are also extended to Dr. John Toogood who provided guidance in the workshops and editing of these proceedings. Thanks also to Ms. Dorinda Wong and Ms. Carol Bechdholt for their patience and accuracy in recording and transcribing these important proceedings.

We also believe that much of the real success of any workshop hinges on the "break-out" sessions. These sessions provided an open forum for all participants to engage in dialogue and discussion of important issues and concerns. Particular appreciation is due to the group leaders and recorders who helped guide and document these discussions:

Ms. Diana Brierley, Mr. Larry Brocke, Mr. Adolf Bruneski, Mr. Dennis Cox,
Mr. Al Fedkenheuer, Ms. Nancy Finlayson, Mr. Len Knapik, Ms. Sandra Landsburg,
Mr. Stuart Lunn, Mr. Terry Macyk, Mr. Mike Melnyk, Mr. Gary Mott, Mr. Chris Powter,
Ms. Judith Smith, Mr. Wayne Tedder, Dr. John Toogood and Dr. David Walker.

While these proceedings could not have been produced without the assistance and important contributions of the aforementioned, Communiplan Inc. accepts full responsibility for any errors or omissions.

R.J. (Bob) Mahnic,
Communiplan Inc.

EXECUTIVE SUMMARY

An industry/government workshop to discuss the parameters and measurement methods to be used to determine pipeline reclamation success was held on May 11 and 12, 1992. The workshop was intended to initiate discussion on the identification of important soil and vegetation parameters. The identified parameters would be used in future workshops to develop standards and criteria to determine pipeline reclamation success.

The workshop was a combined industry and government undertaking coordinated by members of the Alberta Pipeline Environmental Steering Committee (APESC). Government, through the Reclamation Research Technical Advisory Committee (RRTAC), engaged the services of Communiplan Inc. of Edmonton, Alberta to help with facilitation of the workshop and preparation of these proceedings.

The workshop consisted of introductory statements by government and industry, invited technical presentations, a series of "break-out" work group sessions, and plenary sessions. The invited presentations covered both soil and vegetation reclamation success. The presentations were given by professional consultants in the subject areas.

Each of the sixty-eight workshop participants was assigned membership in one of six break-out groups. The break-out groups had two main tasks. On Day 1, the groups identified and ranked (using a flash-card rating system) important soil and vegetation parameters. This exercise helped to identify which parameters were perceived to be most important in measuring pipeline reclamation success, why they are important, and where (ecoregionally within the Province of Alberta) they should be measured. On the basis of plenary session discussions and feedback, it was decided that a second series of ranking assessments be made, with newly combined soil and vegetation parameters that excluded any references to landscape, drainage, surface contouring and land management.

On Day 2, each of the groups were assigned 2 of 12 "select" soil and vegetation parameters based on the previous day's ranking exercise. The groups discussed how the parameter should be measured, when it should be measured, and where it should be measured (on and/or off the pipeline right-of-way). This information was presented in the final plenary session.

The work group exercises yielded the following results. On the basis of the second ranking exercise (with a break-point level calculated by multiplying the number of surveys (57) by the number of parameters (12) divided by 2), out of a listing of 12 soil parameters, six could be identified as important for the measurement of pipeline reclamation success. These six soil parameters were:

- topsoil admixing (including organic matter, colour and tilth);
- topsoil replacement thickness;
- compaction (including density, infiltration, permeability and penetration resistance);
- soil loss by erosion;
- texture (including coarse fragments); and,
- salinity.

Other soil parameters in the final ranking exercise included: erosion protection (including straw, mulch and tackifiers); surface stones and gravel; sodicity; available and total nutrients; pH and lime; and, contaminants.

Using the same ranking system applied to a listing of eight vegetation parameters revealed six parameters that could be identified as important for the measurement of pipeline reclamation success. These six vegetation parameters were:

- plant density;
- yield;
- productivity;
- species composition (including sustainability, diversity of species, suitability, palatability and aesthetic match);
- ground cover (including litter and biomass); and,
- vigour (including plant health, nutrient requirements and phenology).

Other vegetation parameters in the final ranking exercise included: weeds and undesirables (including weed introduction, density and off right-of-way encroachment); rooting characteristics (including rooting pattern and depth); and woody stocking density (including wildlife habitat, forestry and shelter belt density).

While these results should be interpreted with some caution, they do represent an important exercise which may ultimately result in the formal development of quantifiable reclamation standards for pipelines in Alberta. Many workshop participants indicated their interest in having specific criteria and standards developed for the identified soils and vegetation parameters.

The parameters chosen represent only those that the committee decided to use. The number of parameters were arbitrarily cut off at twelve (12) for ease of discussion. More parameters are available for reclamation assessment procedures by both industry and government.

1. INTRODUCTION

An industry/government workshop to identify soil and vegetation parameters to be used in measuring pipeline reclamation success was held on May 11 and 12, 1992. The workshop was intended to initiate discussion on the establishment of a set of provincial reclamation success parameters including standards and criteria. These parameters/standards are to be jointly developed by representatives of the Canadian Petroleum Association (CPA), Independent Petroleum Association of Canada (IPAC), and the Alberta Government's Department of Environment and Department of Forestry, Lands and Wildlife.

The following section introduces the reader to the Workshop Steering Committee, the terms of reference for the workshop, and the workshop agenda.

1.1 WORKSHOP STEERING COMMITTEE

The Alberta Pipeline Environmental Steering Committee (APESC) is a joint industry/government organization which meets to address issues of concern to the group. APESC is co-chaired by Mr. John King and Mr. Klaus Exner and consists of the following members:

Ms. Donna Dowell,
North Canadian Oils Limited, Calgary
Mr. Rob Durward,
Enpro, Calgary
Mr. Klaus Exner,
NOVA Corporation, Calgary
Mr. Don Fregren,
AFLW, Forest Service, Edmonton
Mr. John Hermans,
Alberta Agriculture, Edmonton
Mr. John King,
Alberta Environment, Edmonton
Mr. David Lloyd,
AFLW, Public Lands, Edmonton
Mr. Ian Scott,
Canadian Petroleum Association, Calgary
Mr. Ken Sharp,
Alberta ERCB, Calgary

The planning, development and implementation of the workshop was a combined industry/government undertaking. Government provided pre-workshop support and helped with on-site activities. Government, with the support of the Steering Committee, also engaged the services of Communiplan Inc. of Edmonton, Alberta to help with the workshop facilitation and preparation of these proceedings. Mr. Bob Mahnic and Dr. John Toogood completed the facilitation and editing tasks.

Industry, through the CPA, sponsored the invited technical presenters for the workshop, provided pre-workshop support, sponsored the plenary and break-out rooms, and assisted with meal arrangements.

1.2 PIPELINE RECLAMATION SUCCESS MEASUREMENT WORKSHOP

APESC is a government/industry committee that has been meeting for about two years to work toward resolving environmental and administrative concerns relating to pipeline construction and reclamation. The committee endorsed in late 1991 a workshop that would examine and make recommendations towards determining appropriate reclamation assessment measurements for pipelines.

1.2.1 Terms of Reference

The Pipeline Reclamation Measurement Success Workshop was specifically geared to determining reclamation success measurements that are worthy of further evaluation. Reclamation standards (parameter values that must be achieved) or economics were not discussed. The two latter topics are issues that need to be addressed at a later time. The Steering Committee endorsed the following terms of reference for the pipeline reclamation workshop:

1. To define pipeline reclamation success.
2. To define the need for assessment methods.
3. To determine:
   - i. What soil/vegetation parameters to measure.
   - ii. Why these parameters should be used.
   - iii. How to measure these parameters.
   - iv. When to measure these parameters.
   - v. Where to measure these parameters.

The identification of key soil/vegetation parameters and how they should be measured was the major objective of the workshop "break-out" and plenary sessions.

1.2.2 Workshop Proceedings and Agenda

The task of preparing these workshop proceedings has been enhanced through the use of audio-tape recordings of all keynote presentations and the plenary sessions. It was decided that the break-out sessions would not be tape-recorded, to encourage wider participation. Over the two-day period, almost ten hours of plenary session comments were tape-recorded. As well, more than thirty hours (6 groups x 5 hours) of break-out group work was summarized in a series of flip charts.

Although we were most appreciative of their participation in the workshop, individual speakers commenting in either the question periods or plenary sessions have not been identified. As well, individuals are not named for their specific suggestions or recommendations made in the break-out group sessions.

These pipeline reclamation success measurement workshop proceedings have been organized in chronological order. The workshop opening remarks, objectives and industry/government perspectives on reclamation measurement are noted in Section 2.

The main body of the workshop consisted of formal, invited technical presentations and a series of more informal "break-out" work group sessions and plenary discussions. The technical presentations covered both soil and vegetation reclamation success. The presentations were given by professional consultants in the subject areas. The full text of these presentations are reproduced in Sections 3 and 4.

The workshop facilitator provided an overview of some basic effective communication skills and introduced the assignments for the break-out groups. The break-out groups are noted in Section 5.

Sections 6, 7, 8, 9 and 10 of these proceedings contain the tabulated responses of the break-out groups as well as the key issues discussed in the plenary sessions. These responses indicate the most significant soil/vegetation parameters that break-out group members identified.

Sections 11 and 12 provide some concluding comments to the workshop. The workshop facilitator and representatives of both industry and government summarized the key points of the workshop and provided some insights into the future direction of discussions.

These proceedings are concluded with a series of appendices.

An outline of the workshop agenda is presented in Figure 1.

Figure 1. Workshop Agenda: Pipeline Reclamation Success Measurement

Monday, May 11

1. Welcome and Opening Remarks
   - Bob Mahnic, Communiplan Inc.

2. Workshop Objectives
   - John King, Alberta Environment

3. Workshop Communications
   - Bob Mahnic, Communiplan Inc.

4. Reclamation Measurements:
4.1 Alberta Environment Perspective
   - Larry Brocke
4.2 Alberta Forestry, Lands and Wildlife Perspective - David Lloyd
4.3 Canadian Petroleum Association Perspective - Ian Scott

5. Presentations:
5.1 Soil Measurements
   - Len Knapik, Pedocan Land Evaluation Ltd.
5.2 Vegetation Measurements
   - Dr. David Walker, David Walker & Assoc. Ltd.
5.3 Statistical/Sampling Techniques
   - Dr. Annabel Ness Evans, Concordia College

6. Break-Out Groups:
6.1 Soil Parameter Identification
6.2 Vegetation Parameter Identification

7. Plenary Session and Discussion

Tuesday, May 12

1. Break-Out Groups:
1.1 Soil Parameter Analysis
1.2 Vegetation Parameter Analysis

2. Plenary Session and Discussion

3. Facilitator's Report - Bob Mahnic, Communiplan Inc.

4. Workshop Evaluations

5. Closing Remarks:
5.1 Government
   - Larry Brocke, Alberta Environment
5.2 Industry
   - Klaus Exner, NOVA Corporation of Alberta

2. WORKSHOP OPENING REMARKS

Mr. Bob Mahnic of Communiplan Inc., Edmonton, opened the "Pipeline Reclamation Success Measurement Workshop" by welcoming all participants (Appendix A). Mr. Mahnic also acted as master of ceremonies and facilitator throughout the workshop.

Four presentations by representatives of government and industry opened the Pipeline Reclamation Workshop. First, the workshop objectives were stated. This was followed by three presentations (two by government and one by industry) on pipeline reclamation measurements. These overview presentations touched on two main issues: defining reclamation success for pipelines and defining the need for assessment methods.

2.1 WORKSHOP OBJECTIVES
(Presented by Mr. John King, Alberta Environment, Edmonton)

On behalf of the Workshop Steering Committee and members of APESC, I would like to welcome each of you to this pipeline reclamation success workshop. This workshop is the second of a series of planned workshops to discuss pipeline reclamation issues. We recognize that there are multiple stakeholders in this process, representing various points of view--government, industry and consultants. One of the main objectives of this workshop is to attempt to reach consensus on issues which concern all of us. Equally important is the commitment that will be required to implement these new measures. This will be needed to move forward and reduce or eliminate conflicting methods of evaluation.

We strongly support the approach of reaching consensus at these workshops through consultation and open discussion. We are confident that the "right" answers will evolve through these discussions.

Bob Mahnic has noted in his opening comments that workshops require open communication and the sharing of information between our groups. I certainly agree, and would encourage each of you to actively participate in the work group sessions and discussions.

The terms of reference for this workshop were included in your information packages (see Section 1.2.1). These terms of reference can also be used to indicate our broad workshop objectives. Which soil and vegetation parameters should we be using to determine pipeline reclamation success? Why are these parameters important? How do we measure them? When? Where? We believe that the identification of these parameters is important if we are to evolve and refine our methods of reclamation assessment. This process will take some time to mature, though, through future workshops and discussions. In the meantime, at Alberta Environment at least, it is "business as usual".

Again, I would encourage you to participate in these discussions and be patient with the process . . . it will show positive results as it evolves over time.

2.2 RECLAMATION MEASUREMENTS: ALBERTA ENVIRONMENT PERSPECTIVE
(Presented by Mr. Larry Brocke, Alberta Environment, Edmonton)

I would like to follow-up on John King's previous comments with respect to the concept of reclamation success. We at Alberta Environment are very concerned with the overall concept of capability. It is our intention to establish the concept of capability as a primary measure of pipeline reclamation success.

2.2.1 Problems in Defining Capability

Capability as a measure of success has been difficult to define. We have struggled with various definitions of capability since 1983. It is important that we pull together all of the various approaches into a practical definition of capability. We are hopeful that this workshop will help to bring together some of the different approaches that have been used in the past 10 years.

2.2.2 Environmental Protection Act

I should also mention that the new *Environmental Protection and Enhancement Act* will enforce the concept of capability. The Minister is committed to a dialogue with the province's 2.6 million people about the new Act. It is an important piece of legislation. Presently, some 60 to 70 people

are continuing discussions on the new regulations to accompany the Act. These regulations are going to emphasize the need to measure environmental conditions.

2.2.3 Objective Measurements

The key will be to focus on overall objective measurements - a process which began in 1986. The old capability "measurement" system is being refined. It was not a quantitative evaluation system. Agriculture Canada has recently published a new quantitative system with which we are presently working. Again, we have reworked some of the definitions, especially those regarding capability. We see this as an ongoing, developmental process.

In this workshop, we will be looking at the various soil and vegetation parameters--how to measure them and where they fit--in order to evaluate pipeline reclamation success.

2.3 RECLAMATION MEASUREMENTS: ALBERTA FORESTRY, LANDS AND WILDLIFE PERSPECTIVE (*Presented by Mr. David Lloyd, AFLW Public Lands, Edmonton*)

I would like to relate a little bit about our Department, about reclamation, about how the Department generally handles measurements for success and our expectations for the workshop.

The Department of Forestry, Lands and Wildlife (FLW) is responsible for managing the land surface on all public lands in the province. The Alberta Forest Service manages the forested "green" area of the province and the Public Lands Division manages the public land in the "white", settled areas of the province. The Fish and Wildlife Division assist the Department land managers in ensuring that habitat for wildlife is suitably reclaimed. Documents such as the *Fisheries Habitat Protection Guidelines - Guideline No. 3 - Pipeline Construction and Stream Crossings* help the land managers to assess if a stream crossing has been properly constructed. Staff from our Department must integrate all resource uses so that the most benefit is accrued from the land and its resources with the least amount of damage occurring.

2.3.1 FLW as Landlord

Because FLW is the landlord of public land, we begin our relationship with industry prior to any disturbance occurring. The Department enters into a contract (a disposition) with industry that involves upfront planning and ongoing interaction throughout the life of the disposition. The disposition has specific environmental operating clauses that specify what a proponent must do at the site from start to finish of any project. Our Department has constant, and in most cases, good communication with industry throughout the life of a disposition.

2.3.2 FLW Measurements

This workshop focuses on reclamation measurements only. There are generally two ways in which measurements are assessed on public land. For most reclamation assessment, the first measurement is by visual examination. A disturbance is assessed relative to how current "on site" parameters compare to both pre-site development and present off-site parameters. Both the soils and the vegetation are considered when examining a site. If vegetation is well established, then generally a site is considered to be favourably reclaimed. Soils would be looked at for such factors as topsoil depth, soil mixing, presence of visual salts, compaction or subsidence.

A second method of assessing proper reclamation would involve a more careful, physical, objective assessment of the soils and the vegetation. Soil horizon examination, soil samples for lab analysis, and careful vegetation examination using range evaluation techniques could occur. The second more detailed assessment method would likely occur only when problems are evidenced on a site and for which an obvious solution is not apparent.

2.3.3 Rangelands

Our department assesses reclamation using both vegetation and soils as bench marks. At a reclamation workshop like this, we tend to focus on the conservation of soil. On rangelands and forested soils, we must broaden our thinking to see rangelands and forested lands conservation as applying equally to vegetation. For example, range capability is composed of soil factors but depends first on a healthy plant community--the two, soil and vegetation go hand in hand. Vegetation and other

factors, such as moisture, drive the pedogenic process. Without the unique vegetative community, the soils, as we have them now, would be different. Or to put it differently, native rangelands and even broken and cultivated rangelands are composed of unique vegetative communities that reflect both the soils and the moisture regime found in a given area. Reclamation assessment must therefore consider the soils and vegetative community that is either maintained or that has been re-established. To rely on soil assessment only would give no assurance that the original vegetative community has either been safeguarded or re-established.

To use an analogy, most people in the mineral resource sector can relate to the concept of sterilization as it relates to gaining access to mineral resources. The subsurface resource can be locked up for indefinite periods of time by either not selling the rights to the subsurface or by some surface activity that prevents access to the minerals (e.g., building a city or establishing a national park). In a way the same concept can be applied to rangelands. Soil reclamation practices may be perfectly executed, but if the wrong species is seeded on a wellsite or pipeline (e.g., crested wheatgrass on a native prairie), the range resource becomes sterilized for the normal uses that might be sustained from the rangelands vegetation.

2.3.4 Alberta Forest Service Needs

Another major consideration for reclamation assessment are the needs that the Alberta Forest Service has when determining proper reclamation. Their main concern is that a site is stabilized and properly contoured, that erosion is prevented and that a good vegetative cover is established. Luvisolic soils, taken as a general soil type for forested areas, do not have agricultural qualities or the horizonal and vertical development found on cultivated Chernozemic soils. The Alberta Forest Service thus strives to ensure that a site is properly contoured, seeded to grass--for a pipeline--and stabilized to prevent erosion.

It is clear from the Department of Forestry, Lands and Wildlife's perspective that parameters for both vegetation and soils must be used together to effectively measure pipeline reclamation success.

2.3.5 Field-Staff Training

Each field officer's different training and experience affects how reclamation is evaluated. Determining what reclamation assessment parameters to measure and how and when to measure them, will assist the land managers to more consistently and accurately determine reclamation status. Some training may be required for certain parameters that the workshop may recommend. We as a department are prepared to work toward developing any training that may be needed to assist field staff with their work. Perhaps industry and government can work together to achieve this goal. As an example, our range staff have set up a very successful week long field training course to teach government field staff, and the interested ranching community, how to correctly assess range conditions in the southern regions of the province. An easy to use reporting procedure, complete with simple instructions, has been developed for this purpose. Our range staff have indicated they would be willing to establish a similar course specifically tailored to determining adequate vegetation establishment criteria for reclamation of industrial activities.

2.3.6 Concluding Remarks

The workshop has been established because there is not a clear understanding about what constitutes adequate reclamation for a pipeline. When sites are assessed for proper reclamation, two people can arrive at different conclusions for the same site even though the end reclamation may be quite the same. This difference of opinion can come about because of technical biases (soils versus vegetation training), differing experience, and unclear goals about what constitutes adequate reclamation.

Our objective today is to recommend what reclamation parameters should be measured. When a pipeline is assessed for final clearance, it can then be assessed using the same parameters by all interested parties. We need to understand what to measure, how, when and where to measure the parameters chosen. When we have completed this exercise, I am sure that our field work will become more simplified and commonly understood. Let's work together to meet this objective.

2.4 RECLAMATION MEASUREMENTS: CANADIAN PETROLEUM ASSOCIATION PERSPECTIVE

(Presented by Mr. Ian Scott, Canadian Petroleum Association, Calgary)

On behalf of the CPA, I would like to welcome each of you to this important workshop. I have been asked to present Industry's perspective on measuring pipeline reclamation success. In doing so, I must thank Albert Lees of NOVA Corporation for his assistance in preparing this presentation. As John King said, this is the second of a series of planned workshops. At the last workshop (Three-Lift Soils Handling, November 1990), a number of participants said we must develop better trust between ourselves. This is still true. Trust is not "bought" but attained.

2.4.1 Defining Reclamation Success

Webster's Dictionary defines the term "reclaim" as "to bring into a state of productiveness" but also "to win back from sin or error". Of course, we are here to deal with the former but the latter may have some relevance to some here as well!

If you have read the literature distributed prior to this workshop, and I trust that you have, you will realize that there are some important questions that we *all* must address and this workshop is the first step taking us in that direction. I believe that there are at least five reclamation issues that need to be addressed:

1. What is reclamation success and how do we measure it?
2. What parameters should be measured, when should they be measured, how should they be measured, and who should do the measuring?
3. Should soils and vegetation be used for measuring reclamation success or should one be given preference over the other?
4. Should reclamation assessment criteria be based on eco-regions and/or soil zones?
5. How good or bad are present pipeline reclamation efforts? Are problems province-wide, or localized?

2.4.2 Objectives of Reclamation Assessment

Industry believes that reclamation assessments must be based on specific objectives. These objectives must be clearly stated. They must also be jointly developed between industry, government and public interest groups. Industry and government are here today. I pondered about how consultants are considered--industry or public? Whatever, I believe you do have a role. Regardless, the public must be involved. The question is, who represents the public and when should they be involved?

The objectives of reclamation must deal with geographical location, land-use, soils and vegetation. But are there other considerations as well? For example, reclamation objectives within the Green Area may focus on erosion control and wildlife enhancement, while in the White Area they may focus on preservation of native prairie and prevention of soil loss through wind erosion. Objectives are needed to clearly define reclamation success assessment criteria in an attempt to ensure consistency in reclamation evaluations.

Industry believes that acceptance and compliance with typical soil handling criteria for the various soil types within the province would negate the need for detailed reclamation assessments. Economics is an undeniable, important factor that must be considered. Any reclamation assessment procedure and associated criteria must be easy to understand, easy to implement, and be repeatable, with a minimum cost associated with implementation, manpower requirements and training.

2.4.3 Two-Tiered System of Assessment

I believe consideration should be given to the development of a two-tiered system for reclamation assessments. Such a system would use vegetation as the primary indicator of reclamation success. Industry favours the use of vegetation over soils as the primary assessment tool, because vegetation gives a quick visual indication of problems with soil parameters. The plant is the true integrator of various soil and climatic parameters that affect its growth.

Initial assessments (Tier 1) could be based on visual estimates of various vegetation parameters. Detailed soils investigations or assessments (Tier 2) would only be conducted if problem areas were identified during construction (e.g., overstripping) or after initial assessments show that vegetation has not been satisfactorily established on the right-of-way Identifying which vegetation and soil parameters should be used, how, and when they would be assessed, is the main purpose of this workshop.

2.4.4 Time, Land-Use and Land Management

Three other elements are important in the assessment of reclamation success--time, land-use, and land management. These factors are critical elements of successful reclamation and, therefore, must be included as reclamation assessment criteria. Time frames for reclamation assessments must be developed to ensure that all parties are assessing the same site under the same conditions. In your workshop deliberations, I believe you should consider when a formal assessment should be done--one, two, or more years following completion of the reclamation program.

Land-use and land management can have significant effects on successful reclamation of a pipeline right-of-way. Intensive cattle grazing on private or crown land can and will affect vegetation establishment. Intensive cattle grazing in combination with poor moisture conditions, and poor soils, can have disastrous effects on reclamation success. In cropped areas, land management can influence the appearance of the right-of-way. For example, is the right-of-way being managed as part of the overall field or is it being handled differently from the rest of the field? Assessment of reclamation and the development of criteria must take into account situations where the right-of-way is being managed differently from the rest of the field.

2.4.5 Summary

In summary, assessment of reclamation success requires a clear definition of the objectives, identification of what criteria will be measured, how they should be measured, when they will be measured, and by whom. Industry supports the need for reclamation assessment criteria that will ensure a consistent approach to measuring reclamation success. However, reclamation assessment criteria must be easy to use, economical to implement, repeatable, and must embrace the elements of time, land-use, and land management practices.

I believe that industry supports the use of a two-tiered system of assessment that would use vegetation as the primary assessment tool, the plant being the ultimate integrator of various soils and climatic factors that affect its growth. Finally, I encourage you to participate regardless of your "persuasion". This is *your* workshop. Listen to your peers, comment on their experiences, and share some of your own thoughts.

2.5 INTRODUCTION TO TECHNICAL PRESENTATIONS

Three invited technical presentations were made during the morning of May 11. The following topics were covered: assessment of pipeline soil reclamation, assessing vegetation reclamation success, and statistical/sampling techniques.

Although the presentations were tape-recorded, the text that appears in Sections 3 and 4 of these proceedings is based almost entirely upon the papers submitted prior to the workshop. The reader is encouraged to contact the individual presenters for additional information.

3. PRESENTATION: ASSESSMENT OF PIPELINE SOIL RECLAMATION SUCCESS

(Presented by Mr. Len Knapik, Pedocan Land Evaluation Services Ltd., Edmonton)

3.1 CONCEPTS

To introduce this technical presentation on soil reclamation parameters, a brief review of relevant concepts and assessment terminology was presented.

3.1.1 Assessment and Measurement

Assessment can be defined as "*a judgement of the value or worth of something, either tangible or intangible*". In order to judge the value or worth of real assets we usually rely on measurement techniques. Measurement is defined as "*determining the magnitude, extent, degree, etc. of something in terms of some standard*". We therefore need to know what to measure, how to measure it, and what standard to compare the measurement to, in order to complete an assessment.

The question of what to measure to assess soil reclamation relates to those soil properties that are deemed important and that are relatively easy to measure. How to measure involves techniques and technology, and can also involve sampling design and data analysis.

What standard to compare to is perhaps better stated as "*what expectation is in place*" in current practice. Expectations can vary from region to region (as they should), and from person to person (a situation we want to minimize).

I suggest there are at least two levels of assessing soil reclamation success:

1. screening assessments; and,
2. conflict resolution assessment.

My terms of reference were to focus on the screening assessment level for this workshop. A screening assessment is intended to provide a relatively quick judgement of the reclamation on a pipeline right-of-way. It is essentially a "quality control" or "conformance to standards" check procedure.

3.1.2 Popular Perceptions

Measurement of reclaimed soils appears to be affected by several perceptions that are currently popular. The first of these is what I call the *Stones vs. Salts Perception*. There appears to be fairly general agreement that increasing the stone or gravel content on the soil surface is bad, but there is much less agreement that increasing the salinity of the surface soil layers is bad. I contend this difference is mostly due to the fact that stones are visible and salts are not. In reality, stones are easy to remove while salts are usually not; however, stones may not reduce productivity while salts do. So why the acceptance that stones are worse than salts? Because the stones are visible. It is also generally accepted (often incorrectly) that mixed colors in the topsoil is *prima facie* evidence of loss of soil quality. It must be noted that a lack of visual evidence does not mean an absence of problems.

The *Change with Time Perception* is based on the fact that soils are dynamic and many soil properties can change with time. For example, soluble salts are (obviously) soluble and mobile, and the salt distribution profile will tend to re-establish itself in the reconstructed soil. The rate of redistribution will depend on available water supply, slope position, and soil permeability. The question that arises is, "when is the most appropriate time to measure reclamation success"?

The *Hopelessly Complex Perception* paralyzes those people who say that the soil-vegetation ecosystem is so complex and properties are so inter-related that we cannot possibly hope to understand or measure anything meaningfully. This argument is often employed in an attempt to obstruct progress. It is contrary to both the scientific process and the general advancement of knowledge. The proponents of this perception are suspected of being Creationists and Doomsday Predictors. Variability in soil properties must, of course, be recognized when measuring or sampling, but it can be accommodated.

A soil survey can help to sort out the complexity in the landscape into units that are, in many instances, usually quite homogeneous. Using the soil series approach to recognizing soils helps tremendously in sorting out complexity and recognizing individuals--they really don't "all look alike". Detailed soil surveys are done of all regulated (and some unregulated) pipelines in

agricultural lands in Alberta. The information should be used during the assessment stage to "stratify the landscape into simple units".

As shown in Figure 2, the soil profile consists of a sequence of soil horizons while the pedon is considered to be the smallest 3-dimensional unit in a landscape regarded as a soil. Soil series are groups of pedons, the actual number of pedons being controlled by the range in defined limits of the particular series. Thus while the pedon is a real body in the landscape the series is purely conceptual. Soil mapping delineations usually consist entirely of one series (Series A) or a grouping of two soil series (Series B and C) that realistically represent the true landscape.

The *Soils Versus Vegetation Perception* relates to the fact that the practice of measuring, describing and classifying the plant individual; measuring and describing vegetation stands; and, conceptualizing plant communities is generally accepted--but the analogous practices related to soils are not accepted. This is primarily due to a general ignorance caused by a lack of access to knowledge about soils. The fact that plant communities are more visible than soils is also a contributing factor.

The *Crops as Measuring Tools Perception* is based on the theory that crops or plant communities are the best "integrators" of the soil and climate variables that affect growth, and therefore crop growth is the best measure of soil quality. Comparing crop growth on and off the pipeline right-of-way can provide a good indication of reclamation success or failure. The critics say that different crops have different requirements; the climate never has a "normal" year; and one crop may grow well but the farmer's management options have been restricted. There is also the problem in native plant communities that a newly rebuilt soil should not be expected to behave exactly like a "mature soil" analogous to early seral versus climax plant communities.

3.1.3 Equivalent Land Capability

Expectations of reclamation success are tempered by our view of the overall objective or goal of reclamation. It is anticipated that the new *Conservation and Reclamation Regulations* and *Alberta Environmental Protection and Enhancement Act* will identify the goal of equivalent land capability. Equivalent Land Capability is defined as:

> "*the ability of the land to support various land uses after reclamation is similar to the ability that existed prior to an activity being conducted on the land, but the ability to support individual land uses will not necessarily be identical after reclamation*".

The problem in applying equivalent land capability as a standard has been that it is really a concept rather than a defined set of standards. There is work in progress under the Reclamation Research Technical Advisory Committee (RRTAC) to develop a procedure to measure capability; but development, testing and acceptance of such a procedure will take time. The Soil Quality Criteria Relative to Disturbance and Reclamation was first published as *The Green Book* in 1981. In a revised edition published in 1987 it became *The Beige Book*. These publications were essentially an attempt to simplify the equivalent capability approach. They were developed primarily for coal mine reclamation planning, but have also been applied to pipeline reclamation planning with mixed success.

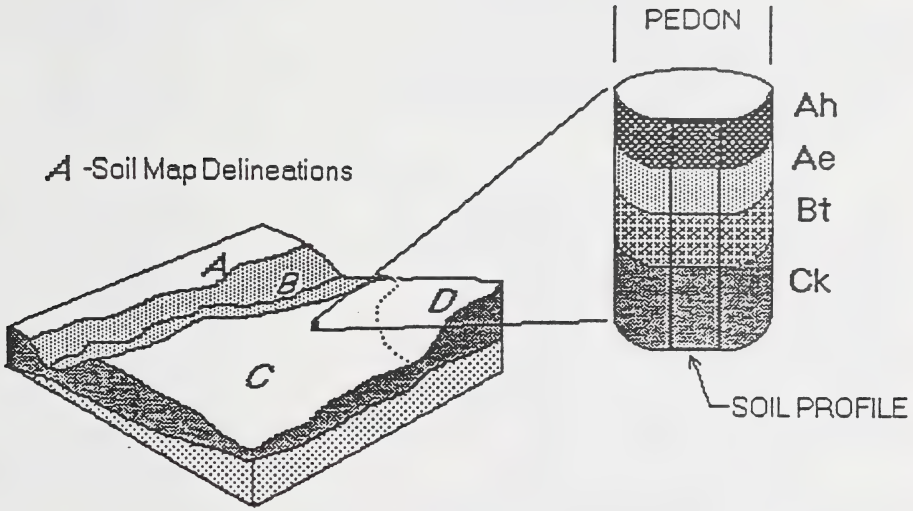
Some dedicated soil conservationists feel that soil reclamation should strive for exact restoration of the soil. It is, of course, impossible to restore all properties of the soil (including vertical pores and channels, subsoil structure, and pore-size distribution) exactly as they were. However, there is a question of how close we can get to an exact restoration while still being practical and cost-effective.

3.1.4 Current Reclamation Approaches

The *Design Standard Approach* sets fairly definite criteria for measurement standards. This approach is analogous to highway construction practice where the contractor knows what the design specifications and tolerance limits are before the job is bid. This approach requires the definition of standard practices for every soil type, and the practices are chosen to assure equivalent capability is achieved.

The *Soils First Approach* to defining reclamation procedures and success requires that soil reclamation must be the first priority. For example,

Figure 2. The Relationship Between the Soil Profile, the Pedon, and the Soil Series



even though narrow ditching without topsoil salvage will cause minimal damage to native vegetation cover, the soils first approach dictates that all topsoil will be salvaged and a wider area will therefore be disturbed. Critics of this approach point to areas of native vegetation that are difficult to replace, and to soils with severe wind erosion risk in sensitive landscapes where the topsoil salvage policy is questionable. The soils first approach may not always be the most appropriate method.

3.2 SOIL PROPERTIES AND INTERACTING VARIABLES

This section of the presentation examines the selection of key soil variables, how to account for ecoregion changes, what needs to be measured and how should it be measured, a review of field techniques and measurement tips, and concludes with an overview comparison to some established standards.

3.2.1 Selecting Key Soil Variables

There is a long list of soil variables that can be described and measured. Most of the variables interact to some extent. All variables vary spatially--while some vary from season to season. The most commonly measured soil variables are listed in Table 1, and are flagged to indicate which major effective properties they influence or provide a measure of. This approach of identifying effective properties is used to help "pigeon-hole" a large number of variables into fewer categories. The effective properties summary matrix can be used to identify key soil variables that can be measured (rather than measuring everything) to provide a reliable indication of the quality of the soil for rooting, nutrient supply, water supply, and absence of limiting conditions. Key soil variables should: influence all four effective properties; be relatively easy to measure; and, tend to be stable through the year.

The surface soil conditions, including the shape and slope of the surface, must be considered in addition to below-surface conditions.

3.2.2 Ecoregion Changes

The relative importance of some of the soil variables changes as one moves from dry grassland soils to moist grassland or parkland soils and to forest soils areas of Alberta. I have not attempted to deal with organic (peat) soils and other wetland soils in this technical presentation.

Delineation of the province into several soil climate areas is provided in the Soil Correlation Areas Map which is the basis for the Generation 2 Alberta Soil Names Files. Each of the 28 correlation areas has a unique set of soil series--therefore the series highly correlates to climatic conditions. The Soil Correlation Areas also match the Ecoregions in the revised version of Strong and Leggat's (1992) maps--so a correlation to natural vegetation types and distribution is also possible.

There can be considerable changes in climate effects, in soil characteristics, and in crop and vegetation requirements from ecoregion to ecoregion. Therefore, we need different standards for the assessment of reclaimed soils in different parts of the province of Alberta.

3.2.3 What and How to Measure

The soil variables shown in Table 2 can be measured with mostly field-tests for screening level assessments of soil reclamation. Most field measurements are very easy to do. These measurements apply to any land use (agricultural cultivation, native grasslands, forest, etc.) although the relative importance of conditions, and the comparison standards, vary by land use. If the field tests identify more complex problems or conflicts that cannot be easily resolved, further, more complicated testing and/or laboratory analysis may be required.

3.2.4 Field Techniques and Measurement Tips

The following field "tips" are provided for use in soils assessment:

1. Soil assessment is a "both feet on the ground" activity. You cannot do it from an aircraft or through a truck windshield.
2. A shovel and auger are the most useful tools for measurement.
3. An acid bottle, a water bottle, and a color book are extremely useful.
4. A simple field lab to test EC and pH can save a lot of time and reduce guessing.
5. A screwdriver sometimes works better than a penetrometer.
6. Salinity and sodicity may need to be checked if the baseline soil survey indicated a potential problem. Material type, wet consistence, and dry consistence often give good evidence of sodic soil problems.
7. The Canada Soil Information System Manual for Describing Soils gives good descriptions of field methods (see Appendix B for soil texture field test examples).

3.2.5 Comparison to Standards

An integral part of measurement is comparison to some established standard or criteria. Regardless of the type of approach used for comparison the question that must always be asked is "how close is close enough"? Does the topsoil thickness of the reclaimed soil have to be 80% or 90% of what is off right-of-way? Does equivalent capability mean that both the type and degree of limitations for a land use must be equivalent? Can we use class categories rather than specific values for standards (e.g., Class 3 stoniness)?

Surface stoniness and topsoil thickness can be compared easily to the off right-of-way situation. However, the characteristics of a natural B horizon are very unlike those of replaced, mixed spoil, and we have to recognize this before we make comparisons. This leads us to subsequent arguments like "equivalent capability versus restoration". Whether we use equivalent capability or not, we must decide if we will compare the characteristics of the reconstructed soil to the original soil or to a set of reclamation design standards.

Table 1. Summary of Soil Variables that Interact to Influence the Effective Properties of a Site

Effective Properties \ Interacting Soil Variables	Structure	Pore-Size Distribution	Air-filled Porosity	Avail. Water Capacity	Bulk Density	Depth to Restricting Layer	pH	Organic Matter	Electrical Conductivity	Soluble Salts	Sodium Content	Soil Temperature	Particle Size Distribution	Coarse Fragment Content	Microbial Activity
1. **ROOTING MEDIUM**															
Root Development	*	*			*	*	*			*					
Aeration and Drainage	*	*	*		*	*		*			*				
Water Storage	*	*		*	*	*		*					*	*	
Nutrient Uptake		*					*			*		*			*
Anchorage	*				*	*							*	*	
2. **NUTRIENT POOL AND SUPPLY**															
Status (availability)							*		*			*			
Amount Available (capacity)						*		*	*			*			*
Transport		*			*	*				*	*				
3. **WATER STORAGE AND SUPPLY**															
a) Surface Soil Water															
Soil Detachment	*							*					*		
Crust Formation	*	*		*	*			*		*	*		*		
Water Content and Retention	*	*		*	*			*		*	*	*	*	*	
Infiltration	*	*	*		*			*		*	*		*	*	
b) Subsurface Soil Water															
Retention and Desorption	*	*		*	*	*		*			*	*	*	*	
Perviousness	*	*			*	*		*			*		*	*	
4. **LIMITING CONDITIONS**															
a) Adverse Soil Conditions							*			*	*	*			
b) Climatic Exposure															

Table 2. Summary of Soil Reclamation Variables and Measurement Techniques

	What to Measure or Describe	How to Measure
Surface Soil Condition	- Crop or Vegetation Condition	- infra-red photography; fly or drive-overs; walk; estimate cover, height, condition; also yield data
	- Water Erosion Protection & Evidence	- drainage pattern & structures, evidence of loss
	- Wind Erosion Protection & Evidence	- surface cover, evidence of loss
	- Evidence of Slope Instability	- visual evidence of movement/failure
	- Conforming Slope Pattern	- check slope, cuts, fills conform to adjacent land
	- Drainage/Ponding	- check drainage continuity, ponding areas
	- Height of Roach	- measure height and width
	- Subsidence or Rutting	- measure depth and extent
	- Stones, Gravel or Roots	- estimate or count, compare to off-ROW (right-of-way)
	- Soil Color/Mixing	- visual evidence of color change across ROW
	- Soluble Salts	- visible salts and sample for EC
	- Lime	- acid test or sample for pH, $CaCO_3$
	- Contaminants or Spills	- visible evidence and sample to confirm
Topsoil Condition	- Topsoil Layer Thickness	- tape measure (several spots)
	- Soil Color & Mixing	- color book
	- Consistence/Tilth	- consistence description
	- Material Type & Texture	- identify type(s) & manual texture
	- Stone or Gravel Content	- visual estimate or sample volume %
	- Lime	- acid test or sample for pH, $CaCO_3$
	- Soluble Salts	- visual evidence or sample for EC (maybe SAR)
	- Root Distribution/Restriction	- visual description
	- Organic Matter	- visual and sample for Organic Carbon
	- Bulk Density	- Core method (needs dry weight)
	- Water Infiltration (qualitative)	- infiltration rings — compare to off-ROW

continued...

Table 2. Concluded

	What to Measure or Describe	How to Measure
Subsoil Condition	- Thickness of Lift #2 if three-lifted	- tape measure (several spots)
	- Soil Color & Mixing	- color book
	- Material Type & Texture	- identify type(s) and manual texture
	- Consistence	- consistence description
	- Stone or Gravel Content	- visual estimate or sample volume %
	- Lime	- acid test or sample for pH and $CaCO_3$
	- Soluble Salts (Salinity)	- visible crystals and sample for EC
	- Sodicity	- material type, wet consistence, dry consistence and sample for SAR & SAT%.
	- Root Distribution/Restriction	- visual description
	- Water Movement Restriction	- visual description after rain or infiltration test
	- Overcompaction/ Undercompaction	- screwdriver, penetrometer, density core
Lingering Problems	- Fertility	- sample for C/N ratio, pH and available NPKS; micronutrients and tissue testing also possible
	- Water Supply	- texture, OM, infiltration rate; possibly EC & SAR; moisture potential

Design standards could be prepared for various "performance groups" of soils which would specify target levels for key soil variables or properties. Assessment of the quality of a mixed spoil subsoil would then be done against a design target rather than comparing to an undisturbed soil. The design standard may even be defined in terms of non-soil criteria such as maintaining vegetation cover and erosion control for some situations.

3.3 WRAP-UP COMMENTS

In conclusion, I would like to make a few suggestions and recommendations concerning the measurement of pipeline reclamation success:

1. We must recognize our reclamation problems and requirements clearly and understand how they relate to soil characteristics and landscape position, and to pipeline construction practices.
2. Sound planning and construction practices in combination with quality controls should negate the need for many loud arguments about reclamation success.
3. "Screening Level Assessments" should rely mostly on field tests that can be done relatively quickly.
4. Comprehensive "Conflict Resolution Assessments" that would stand up to a challenge of validity must also be statistically valid. This requires a geostatistics approach to soil sampling and data analysis--which is time consuming and expensive. The current number of Reclamation Assessors (company and government) would have to be increased greatly to handle such assessments.

3.4 TECHNICAL REFERENCES

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3.5 QUESTION PERIOD

(Responses by Mr. Len Knapik, Pedocan Land Evaluation Ltd.)

Question #1. When should the soil parameters be measured?

Answer #1. There should be an initial assessment immediately after cleanup, followed by more long term assessment after roach settlement--probably after a year or two, depending on the soil type. Stones should be assessed after clean-up. Salinity cannot be fairly assessed until after equilibrium of the mobile salts has been reached, and this will depend on a number of factors including the moisture regime and drainage.

Question #2. What about the use of cameras for photographic record?

Answer #2. Yes. Photographic records can be of some help in soils assessment.

Question #3. What screening levels do you recognize as necessary for field assessments?

Answer #3. Three are suggested: fly-over, drive-over, and walk-over.

Question #4. When should field inspections be made?

Answer #4. There should be an immediate inspection as soon as cleanup is completed, and then periodic inspections afterward depending on the problems encountered.

Question #5. How important a factor is the height of the roach over the ditch-line?

Answer #5. This depends on the soil type and the time of year. The rate of settlement will depend on soil texture and structure, on climatic conditions, and management of the right-of-way.

Question #6. Do you evaluate reclamation success over the whole pipeline or only on problem areas?

Answer #6. The tendency is to focus on problem areas. First, one would make an overall assessment for the whole pipeline but then look in detail only at the problem sections.

4. PRESENTATION: METHODS OF ASSESSING VEGETATION RECLAMATION SUCCESS

(Presented by Dr. David Walker, David Walker & Associates Ltd., Calgary with Dr. Annabel Ness Evans, Concordia College, Edmonton)

4.1 RECLAMATION "AS-BUILT" REPORT

In Alberta, Government currently has an ongoing role in ensuring minimal environmental impact from pipelines. Route selection is examined--Development and Reclamation Plans are required. Government's regulatory role necessitates that sufficient information is acquired to base a decision.

Pipeline companies currently meet required environmental protection measures by hiring environmental inspectors and specifying the protection requirements in construction contracts.

Despite efforts on the parts of both sides, the regulator and the regulated, agreed upon environmental protection measures are sometimes not carried out for a variety of reasons. Avoiding problems has repeatedly proven to be more economical and effective than mitigation after the damage has been done. Improving the implementation of existing agreed-upon mitigation measures might be the most effective change that could be made to the current system of environmental regulation of pipeline construction.

4.1.1 Credible Inspection

Inspection must not only be free of bias to be effective, but must appear to be credible. Many pipeline companies already hire outside (i.e., non-company employed) environmental inspectors. Credibility of inspection could be improved if environmental inspectors were independent contractors who were paid by the company but reported to government regulators.

4.1.2 Environmental "As-Built" Report

The independent environmental inspector should be responsible for recording all environmental aspects of the construction of the pipeline. The role of the inspector would not be one of "policeman", as is sometimes the case currently, but one of identifying environmental concerns where mitigation may be necessary because the reclamation plan was not followed or because unanticipated circumstances arose.

Reclamation success standards should then include not only soils and vegetation standards but also the review and approval of an Environmental "As-Built" Report. Faster and easier approvals could be possible if there were assurances that there were no surprises (fuel spill, poor topsoil handling, drainage problems).

For example, early approval of the productivity standard might be possible if there was the assurance that the correct seed mixture was used and that sufficient seedlings had emerged. A valid inspection report documenting adequate topsoil handling could eliminate the need for extensive field sampling.

4.1.3 Contractor Liability

The pipeline construction contractor is always the "wild-card" in achieving reclamation success. Where there is good cooperation, there usually is good results. If the pipeline construction contract shifted the environmental liability for a deficiency from the client company to the construction company unless the deficiency was reported by the environmental inspector, then perhaps there would be fewer unreported incidents that cause problems in achieving reclamation success.

4.2 CULTIVATED LAND

Three elements of gauging reclamation success on cultivated land are reviewed. They include plant density, crop production, and vegetation composition.

4.2.1 Density

Plant density of crops on cultivated land is a quick and early method of identifying problems. As applied to cultivated land, plant density could be an ocular estimation of on and off right-of-way situations assuming the right-of-way received the same agricultural production inputs. The density criteria is best measured the first season after

construction, between 1 to 8 weeks (three-leaf to tiller stage) after germination, and is best used as a tool to identify soil problems.

4.2.2 Production

Crop production can be measured in several ways, weight of crop (grain or forage) per unit area being the most definitive. Standards could vary from requiring, within a stated time frame, equal or better yield to something like 90% yield of adjacent, undisturbed land. Sampling for such a standard would involve harvesting paired samples (on and off right-of-way) and comparing yield.

There are problems with enforcing a crop production standard on cultivated land. Timing is one problem. Reclaimed soils are "new soils", even if pipeline construction disturbances are short term. Soils may not be fully productive for several years and the expectation of immediate equal or better yield may be unrealistic.

Control of agricultural production inputs is another problem. Generous amounts of fertilizer applied just after construction could boost yields above adjacent undisturbed land. The yield advantage may not be sustained under normal cropping practice. Other less stringent means of assessing production are useful in identifying problems but not as a reclamation success standard. Height of crop is too easily influenced by moisture supply and competition from taller species.

Production can also be measured visually. Comparison by trained individuals of crop appearance, height, colour and vigour, both on and off the right-of-way, are valid methods of assessing performance. Infra-red photography, by aircraft or satellite, is another means of assessing and identifying crop production. Production is best measured at harvest time although early sampling can provide valid data. Visual assessments should be done at mid-season (in the early tiller to emergence stage) to get good crop colour and appearance information.

4.2.3 Composition

A standard for vegetation composition is applicable to cropland for two criteria--weeds and crop sensitivity. Standards for the presence of weeds are well entrenched in other jurisdictions and are not dealt with here.

Crop sensitivity recognizes that some plant species are more sensitive to some soil conditions than others. For example, the loss of topsoil during construction may result in a reduction in the yield of field peas but not of barley because of sensitivity to drought. Other examples include sensitivity to soil salinity, chemical spills, or poor drainage. Crop sensitivity can be used as a method of detecting and demonstrating environmental damage but the test is not suitable as a standard that can be widely applied.

Table 3 provides a summary of the vegetation parameters that can be used to assess reclamation success on cultivated lands.

4.3 NATIVE RANGELAND

Plant density, cover and erosion control, the relationship between density and cover, crop production, vegetation compostion and range cover are discussed in this section.

4.3.1 Density

Plant density is defined as the number of plants per unit area. The parameter is measured by hand-counting plants within a sampling quadrat (frame) or along a line transect (tape measure). Sampling procedure and quadrat size and shape are described later in this presentation.

The density parameter is important because it is an early indicator of whether the cover and productivity parameters can be met. Early detection of a seeding failure allows time for remedial action before serious erosion damage occurs.

The optimum plant density for maximum forage production in an arid region of western Canada is approximately 20 plants/m^2 (Leyshon *et al.* 1981). However, a density of 20 to 40 plants/m^2 is normal for maximum seed production of creeping red fescue in the Peace River area. A value of 10 plants/m^2 may be suitable as a minimum plant density because experience has demonstrated that such a density will develop a satisfactory stand without excluding the invasion of native species.

Table 3. Summary of Vegetation Parameters for Assessing Reclamation Success on Cultivated Land

What to Measure	When to Measure	How to Measure
Compliance with Reclamation Plan	Throughout construction	• Regulatory review of Reclamation "As-Built" Report prepared by independent, on-site inspector
Plant Density	1 to 6 weeks	• Hand count, quadrat samples, random, paired, on/off ROW
Production (biomass or seed yield)	Harvest time	• Ocular Assessment of health, height, vigour, stage, colour • Harvest Method, quadrat samples, random, paired, on/off ROW • Indicator Species Method, sensitive to specific problems, salinity, low OM, heavy metal
Composition (weed invasion)	Any time	• Ocular Assessment, identify problem species • Hand count, quadrat samples, random, paired, on/off ROW

Invading native plants should be included in the cover assessment, the area of canopy cover of woody species should be included, and areas of bedrock, blasted rock, and shallow soil over bedrock should be excluded. Litter should be included in the cover assessment.

While the density value is low, a high frequency value is recommended. Ninety percent (90%) of the square metres in any area measuring 10 m by 10 m should contain at least ten plants. This means that 10 m^2 could be devoid of vegetation and still pass the standard. Another method of measuring the 90% frequency requirement would be to employ a sampling procedure to assess homogeneous but questionable sections of the pipeline right-of-way.

4.3.2 Cover and Erosion Control

Vegetation is the most important factor in erosion control. As such, the ground cover (litter plus live vegetation) parameter is the most important factor for adequate erosion control. Extensive research on the effects of ground cover (vegetative canopy cover and associated mulch) has indicated that when the ground cover is over 90%, the erosion control is 99% effective. Erosion control drops quickly when ground cover is below 70% (Wischmeier and Smith 1978). Figure 3 illustrates the relationship between percent cover of vegetation, percent cover of mulch and soil loss ratio.

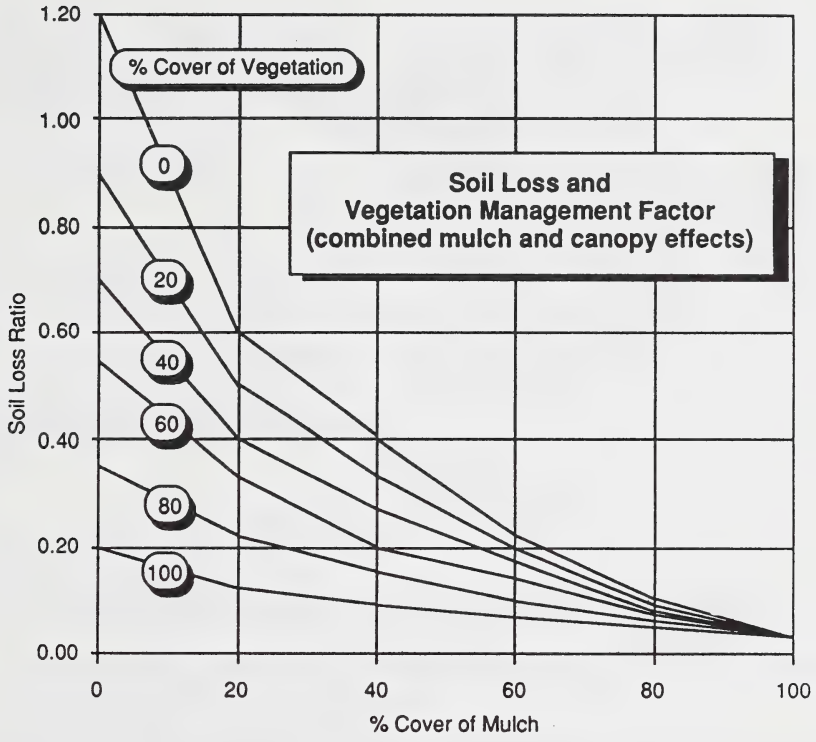

Figure 3. Soil Loss and Vegetation Management Factor
(adapted from Wischmeier and Smith 1978:19)

A value of 80% ground cover is suggested as a reasonable compromise to provide an adequate level of erosion control.

Too much vegetative ground cover will inhibit the invasion of native plant species onto a reclaimed site. Another reason for adopting a ground cover value that is only just sufficient for erosion control is the effect of high ground cover values on the quality of wildlife habitat. Research has demonstrated that wildlife use of reclaimed sites declines as the cover of dense vegetation increases (Forren 1981; Kimmell 1982; Mindell 1978; Whitemore 1980; Wray *et al.* 1980).

Ground cover may be assessed by a number of well established techniques including the point-quadrat method, line-intercept method, 35mm slide technique, the optical cover point method, and the ocular estimate method (Chambers and Brown 1983).

4.3.3 Relationship Between Density and Cover

The plant density and ground cover standards are compatible with each other. A plant cover of 80% is possible for most grass and legume species at a minimum plant density of 10 plants/m^2.

Figure 4 illustrates the number of plants of 17 species of grasses and legumes that are required to provide a canopy coverage of 80%. Plants were space-planted at 2 m and coverage was measured after two growing seasons in the Edmonton area. Annual growth is expected to be less under climatic conditions more limiting to plant growth than

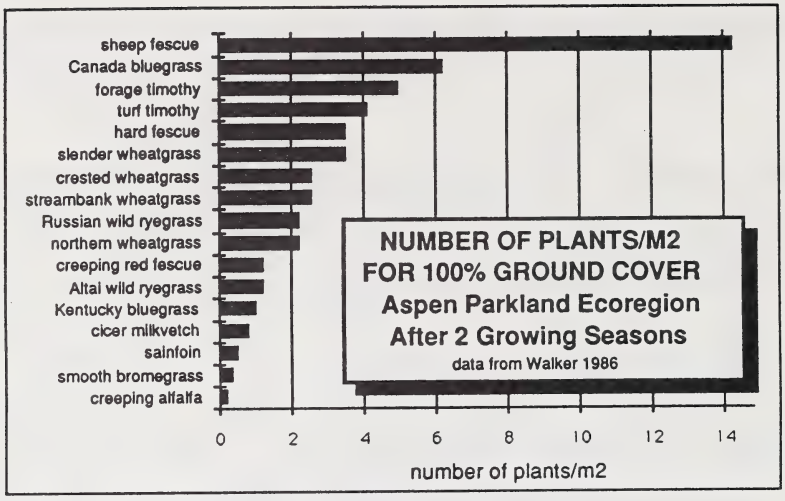

Figure 4. Number of Plants Required for 100% Ground Cover: Parkland Ecoregion

experienced in Edmonton but there is considerable latitude in the number of plants required to produce the required cover. Sheep fescue was the only species that would require a density higher than 10 plants/m^2 to provide a minimum 80% canopy cover. In addition, accumulated litter is expected to contribute substantially to ground cover after the first 2 to 3 years. The rationale for the low density is that a small number of large, healthy plants will provide a better vegetative cover for erosion control and tolerance to adverse climatic conditions than would a stagnant stand of crowded plants.

It is important to note that vegetation must be capable of maintaining cover and density without the aid of applied fertilizers. A minimum of 3 growing seasons should elapse after the last inputs of seed and fertilizer before measuring vegetation cover.

Residual growth effects from high rates of nitrogen fertilizer can last 4 years (Smith *et al.* 1968) and even 9 years (Power 1981). A waiting period of 3 growing seasons without fertilizer input is suggested as a compromise that would provide release from reclamation responsibility in a reasonable time period yet provide good assurance that the site is self-sustaining.

4.3.4 Production

Forage production is not a good measure of reclamation success on rangeland. Studies have shown that highly productive agronomic grasses can produce up to five times the forage of native grasses even without fertilizer. Inputs of fertilizer and other chemicals can mask production results for many years. Production alone does not measure the ability of a reclaimed pipeline right-of-way to sustain grazing.

4.3.5 Composition

Weed presence should be considered an important parameter for assessing reclamation success on rangeland. Methods of weed assessment and standards are not covered in this presentation.

Grazing animals are attracted to reclaimed sites because the revegetation seed mixture contains

palatable and highly productive species. This leads to overgrazing both on the right-of-way and the areas adjacent. Recovery of rangeland vegetation after pipeline construction requires grazing deferment to be successful. It would be better if the reclaimed pipeline right-of-way had a neutral (or even negative) effect on animal utilization and distribution.

Vegetative composition is important to identify palatable species and predict possible effects on animal distribution. Limiting the usefulness of this parameter is the fact that the number of revegetation varieties is extremely limited. Also the knowledge base of how various animals react to them is missing. The information that is available primarily identifies which varieties are highly palatable.

Ocular observation is the most practical method for assessing reclamation success of the vegetation composition parameter. If the revegetation seed mixture has been carefully reviewed during the regulatory process and the area properly seeded, the parameter is not necessary.

4.3.6 Range Condition

Range condition parameters and methods of assessment could be used to compare on and off right-of-way sites for reclamation success. Unless the revegetation mix contains a significant number of native grass varieties, the range condition parameter may not be useful for several years. Plant succession and the response of plants to grazing pressure could be long term. The specifics are not discussed here.

Table 4 provides a summary of the vegetation parameters that can be used to assess reclamation success on native rangelands.

Table 4. Summary of Vegetation Parameters for Assessing Reclamation Success on Native Rangelands

What to Measure	When to Measure	How to Measure
Compliance with Reclamation Plan	Throughout construction	• Regulatory review of Reclamation "As-Built" Report prepared by independent, on-site inspector
Plant Density	3 to 12 weeks	• Hand count, quadrat samples, random sampling scheme
Ground Cover	1 to 5 years	• Ocular Estimate, quadrat samples, random, example key • Point-Quadrat, random sample • Optical Cover-Point, random • Line-Intercept, random • Photographic, random, ground or low-level aerial, film or laser or video camera
Production (biomass)	3 to 5 years after last inputs of seed and fertilizer	• Harvest Method, random, paired on/off ROW • Weight-Estimate Method, random, paired on/off ROW
Composition	1 to 5 years	• Ocular Assessment, identify unwanted species • Hand count, quadrat samples, random, paired, on/off ROW
Range Assessment	5 to 10 years	• Standard Range Condition Methods

4.4 FORESTED LAND

Plant density, ground cover, species composition and stocking density measurements for forested lands are discussed in this section.

4.4.1 Density

The density parameter that applies to rangeland is applicable to forested land when erosion control is the primary reason for having a standard. A different density standard may not be necessary despite the ecological difference between dry prairie and moist forest. Rate of growth and biomass production are higher and as long as the cover standard is met, the number of plants/m^2 is irrelevant. The density parameter for forested land is measured in the same manner as described above.

4.4.2 Cover

The cover parameter for erosion control described in Section 4.3.2 for native rangeland applies equally to forested lands.

4.4.3 Composition

Plant species composition has importance as a reclamation success standard on forested land for the impact it may have off right-of-way. Weed infestations are controlled by other jurisdictions and are not discussed here. The species in the revegetation seed mix can have an impact on forest growth. Competitive varieties could hamper forest regeneration. Palatable varieties could alter the distribution of wildlife.

Measurement of vegetation composition has already been described. Requirements for a predetermined vegetation composition may be too locally specific to be applied as a widely applicable standard.

4.4.4 Stocking Density

Pipeline right-of-ways are typically maintained free of trees and tall shrubs in order to monitor the route from the air and conduct routine maintenance or emergency response activities. There may be some circumstances when restocking may be required such as a natural area or a critical wildlife habitat zone. The new reforestation standards should be used where tree planting is required for reclamation.

Table 5 provides a summary of the vegetation parameters that can be used to assess reclamation success on forested lands.

4.5 SAMPLING

The following describes a proposed sampling procedure for deciding if a reclamation site meets or does not meet acceptable reclamation standards. If these recommendations are followed, the assessor can be confident that the decision is sound and accurate with a 90% level of confidence. An overview of the statistical details used in this presentation are noted in Appendix C to these proceedings.

4.5.1 The Sample Unit

A single sample unit of one quadrat is assumed to be the standard unit in most cases. Selecting the proper sampling unit is important for efficient and accurate vegetation sampling. As shown in Table 6, the quadrat size and shape may vary according to the vegetation type (Van Dyne *et al.* 1963).

4.5.2 Assessment Measures and Standards

In the sampling procedure described here, each sample unit is given a Yes/No rating: Yes, the sample unit meets the standard or No, the sample unit does not meet the standard. The standard depends on the criterion. In some cases the criterion is a comparison of a parameter measured on and off the right-of-way; in others, the criterion is a minimum or threshold value which may apply to specific sections of the pipeline route or areas of the province.

For example, for ground cover, we suggest that the standard for acceptable ground coverage of a single one-metre square area be 80%. For crop production, the standard may be that on right-of-way yield is at least as good as that observed on the adjacent, undisturbed field.

Table 5. Summary of Vegetation Parameters for Assessing Reclamation Success on Forested Lands

What to Measure	When to Measure	How to Measure
Compliance with Reclamation Plan	Throughout construction	• Regulatory review of Reclamation "As-Built" Report prepared by independent, on-site inspector
Plant Density	3 to 12 weeks	• Hand count, quadrat samples, random sampling scheme
Ground Cover	1 to 5 years	• Ocular Estimate, quadrat samples, random, example key • Point-Quadrat, random sample • Optical Cover-Point, random • Line-Intercept, random sample • Photographic, random, ground or low-level aerial, film or laser or video camera
Composition	1 to 5 years	• Ocular Assessment, identify weedy species • Hand count, quadrat samples, random, paired, on/off ROW • Diversity Comparisons, random paired on/off ROW
Stocking Rate	5 to 10 years	• Hand count, quadrat, random • Optical Wedge, plot-less, or distance measure, random

Table 6. Vegetation Types and Sample Units

Type of Vegetation	Plant Cover	Size of Quadrat
Dense pastures and prairie	> 50%	0.25 to 0.75 m^2
Sparse pastures and prairie	< 50%	0.5 to 1.5 m^2
Forested areas	N.A.	0.75 to 2.5 m^2

See Chambers and Brown (1983) for review.

4.5.3 Sample Size and Random Sampling

The sampling and assessment procedure described above requires that eighty (80) sample units be assessed. This assures that we are very confident (i.e., 90%) in our decision about the true state of the reclamation site.

The 80 sample units that are assessed must be chosen randomly. The sampling may be either a simple random sample or a systematic random sample. A simple random sample means that if the entire site was divided into one-square metre units, each unit has an equal probability of being included.

A systematic random sample has many random starts along a transect followed by a simple random sample. For example, a sample site might be chosen by starting at a series of random positions down the centre of a pipeline right-of-way and then a sample is chosen at random somewhere across the right-of-way. The random selection scheme can be set up in advance by making an educated guess about the size of the reclamation site and picking 80 units using a random number table.

4.5.4 The Pass or Fail Decision

If 12 or more of the 80 sample units fail to meet the standard then the assessor is confident that the reclamation site as a whole does not meet the standard. In other words, 90% or more of the time when 12 of more of the sampled units do not meet the standard, the entire site would not meet the standard if it were measured in its entirety.

The site does not meet the standard when:

No. Sample Units Passing	No. Sample Units Failing
68 or less	12 or more

4.5.5 Consequences of the Decision

Whenever we are not able to assess an entire reclamation site, we must sample that site and use the sample information to "guess" about the true state of the entire site. Our goal, of course, is to do more than guess. Our goal is to make decisions that are as accurate as possible. This is where statistics can help us. Accurate decisions about the true state of a reclamation site can be made if we follow certain rules and procedures. We must have an adequate sample size. We must know how our measurement variable distributes itself and if this distribution assumes random selection, we must randomly select. If we do not follow these rules and procedures then we really can't make decisions with any degree of confidence that we are correct. Table 7 illustrates the four outcomes that could result from the sampling procedure and the confidence we have in making decisions about the site.

Table 7. Sampling Procedure Confidence Estimates

		The True State of Affairs If we assessed the entire site would it meet the standard?	
		YES	NO
When we sampled the site, did it meet the standard?	YES	We will make this correct decision 18 times out of 20	We will make this error two times out of 20
	NO	We will make this error two times out of 20	We will make this correct decision 18 times out of 20

The question at the top of Table 7 asks whether or not the site truly *does* or truly *does not* meet the standard. In other words, if the entire area were assessed would it or would it not meet the standard? The question on the left side of the table asks whether or not the site met the standard when we sampled it. If the reclamation site does truly meet the standard, we will conclude just that after sampling it 18 times out of 20. Two times, we will make a mistake and say the site fails. If the reclamation site in reality does not meet the standard we will conclude just that 18 times out of 20. Two times we will make a mistake and say that it passes. Simply we will make a correct decision 18 times out of 20 and we will make an error two times out of 20. There are two kinds of correct decisions and there are two kinds of mistakes.

4.5.6 Confidence Estimates

Deciding what degree of confidence we are comfortable with when making decisions of this sort usually depends on the impact our decisions will make on others. If the consequences of making a particular kind of mistake are dire, then we are wise to reduce that likelihood. For example, if the consequences of saying that a reclamation site does not meet the standard by mistake are more significant than the consequences of saying the site does meet the standard by mistake, then we would adjust these likelihoods accordingly. In this report, it is assumed that both errors are equally significant and so we have kept these likelihoods equal at 10%. This error rate could be increased or decreased by adjusting the sample size.

4.6 EROSION LOSS STANDARD

Soil loss by erosion must be controlled to an acceptable level to preserve soil productivity and avoid sedimentation of surface water. During pipeline construction, some soil erosion on-site is an unavoidable risk. Native vegetation off-site may be buried and low-lying areas may experience sediment accumulations. Sedimentation of aquatic habitats is best monitored by water sampling and is beyond the scope of these standards and this presentation.

Post-construction erosion loss standards are necessary under certain conditions. An acceptable level of soil loss is dependent on several factors. Soil loss tolerance for a reclaimed area depends on balancing erosion losses with soil formation by weathering and accumulations of organic matter. Current soil conservation practice tolerates soil loss in the range of 2 to 22 Mg ha^{-1} yr^{-1} (0.1 to 1mm yr^{-1}) depending on the rate of weathering and climatic conditions (Kirby 1980). The objective of achieving a self-sustaining vegetative cover on a reclaimed site requires that organic matter accumulates as rapidly as possible.

Assessment of the erosion loss standard will probably be unnecessary if the revegetation success standards are met. However, if serious erosion losses continue despite passing revegetation success standards, an erosion loss standard would help to protect the environment. Erosion losses may be determined using a number of methodologies including: erosion pins; sediment collectors; rill meters; and, sediment yield in water (de Ploey and Gabriels 1980).

4.7 EXEMPTIONS

The adoption of standards should not mean that common sense exceptions are not recognized. Exemption from reclamation success standards or modification of the standards will undoubtedly be warranted in a number of instances. Conflicts with other land uses or standards other than reclamation success are inevitable. For example:

1. After pipeline construction, a landowner may wish to cultivate a once forested right-of-way. Agricultural productivity cannot be compared with the adjacent forested area. Comparison to another field may not be valid because it is too far away. In addition, it commonly takes several years of land management before cleared land reaches an acceptable level of productivity.

2. Pipeline construction, because of the grading requirements, may enhance the land for other uses. For example, the right-of-way might create access to a previously remote area of a landowner's property. The right-of-way may create a new route to water for cattle. A pipeline right-of-way

can be useful for other land uses and should be exempt from revegetation success standards as long as there is minimal risk of soil erosion or pipeline damage.

3. A pipeline route that crosses areas where cattle congregate for water, feed, or gate access may not meet revegetation success standards because of trampling. Fencing might affect the use of the land.

4. Endangered species considerations might, for example, supersede revegetation success standards. It would not make sense to disturb rare or endangered animal species (burrowing owl or Swift fox) which found a pipeline right-of-way suitable habitat but in the process destroy vegetation so that it would fail the revegetation standard.

5. Fencing a pipeline right-of-way until vegetation has established is becoming more common. Cattle crossings, usually located in areas of low erosion potential, allow access to both sides in a large field. The cattle crossings may not meet the standards because of cattle trampling.

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4.9 QUESTION PERIOD
(Responses were given by Dr. David Walker and/or Dr. Annabel Ness Evans)

Question #1. What do you mean by large or small sample sizes?

Answer #1. Well, I know you'll assume a normally-distributed sampling population with replacement. However, you don't have either of those things. But that's alright as long as the proportion that you are actually looking at is small compared to the site itself. I understand from Dr. Walker that you can have many miles of site (right-of-way) and you sample square metre bits here and there. In that case this distribution is a good one and will approximate what is going on.

Question #2. You had mentioned that we need to take 80 vegetation samples along the right-of-way?

Answer #2. Yes, 80 samples, that's the magic number.

Question #3. Would that apply to any one kilometre length of right-of-way? In that case your samples are just closer together but it's still 80 samples, is it?

Answer #3. It is, yes. You should still take 80 samples but your unit size should be smaller and technically that should be adjusted each time you do this. I understand that this one-metre square sampling frame is your standard measuring device and so I'm assuming that most of the time you'll use this and that will work fine--you're going to get a decent approximation unless your population is really silly and then you would not use an inferential statistical analysis anyway.

Question #4. Does this assume you haven't stratified what you're looking at?

Answer #4. It would probably be to your advantage to stratify to see certain pipeline sections that you would like to assess and get approval and leave the sections you might not get approval for.

Question #5. What if you had 10% of your site that was rolling or sloped and 90% flat? Would you still do 80 samples on your 10% that was rolling terrain?

Answer #5. The thing that neither of us mentioned is that the sample must be totally random.

Question #6. How can you deal with a sampling site that may be only 10m by 10m?

Answer #6. You wouldn't sample a site 10m by 10m or smaller. I should mention that there might be two ways of doing an assessment and in fact that's the way the Roger's Pass (CP Rail) was done. The first assessment would allow the assessor to go anywhere and pick a site 10m by 10m and measure that one site. So, simply go to the worst part of the whole site and measure off 10m by 10m and 90% of those metres have to pass the standards. Now if there were no spots like that, then you would go to the procedure of sampling 80 samples and if you did that on a long pipeline right-of-way that had ups and downs and all sorts of things like that, and it failed--then the pipeline company may want to come back and stratify

the sample into sections--good sections and bad sections--and then we only need to work on the bad sections.

Question #7. How long does it take to sample 80 sites in the field?

Answer #7. With the sampling frame it took probably two days in total including travel time. It was not a long process. We also measured a bunch of other things like productivity and vigour.

Question #8. When you're talking about doing the assessments, are you differentiating the trench from the removed topsoil? How do you deal with that?

Answer #8. Sample several positions on the right-of-way. Assuming that inspection has been adequate and the soil has been handled properly there shouldn't be a difference. Whether you tolerate brief sections of bare ground is another matter.

Question #9. Isn't that a problem of randomization? How do you randomize it? How do you know you're random and how do you know you haven't collected that already?

Answer #9. The best way to do it is before you go out into the field is to work with a set of random numbers. Then it's a matter of locating them--a random number say, so many kilometres down and so many metres to the left or right of the pipeline centre line. Smoliak did a lot of work on looking at different methods, but that was some years ago.

Question #10. For the cover and density standards --are those absolute values or do they change on a region to region basis?

Answer #10. No, I don't suggest that they change in either region. Absolute values, yes, because the cover standard for erosion control is 80% on that graph; it doesn't matter whether you're in Saskatchewan or whether you're in Peace River. Now that was for water erosion control on that graph. You might go to wind erosion control at 30% and this is generally considered an adequate cover--45% is found to be the average cover on a poor year in the sand hills. The frequency that I've been telling you about--90% frequency, 90% success--is very very high and I'm not entirely sure that if I were to go out and assess a natural area that that natural area would be that consistent. So in a way the standards are set quite low but the level of consistency is very high. The statistical testing is quite tight in that regard. There are areas in the United States where they say we only want 80% of the areas to be tested and some areas they say only 70% frequency. In this case, 90% is extremely high.

5. OVERVIEW OF BREAK-OUT WORK GROUPS

This section of the proceedings provides an introduction to the group leaders/recorders and the break-out group participants.

Each of the sixty-eight workshop participants was assigned membership in one of six "break-out" work groups. The break-out groups discussed both of the technical presentation topics--soil parameters and vegetation parameters--in a series of one-hour sessions. The break-out groups had two main tasks. First, the groups identified and then ranked (using a flash-card system) important soil and vegetation parameters. Second, the groups were assigned "select" soil and vegetation parameters to discuss and present in the final plenary session.

Many suggestions were made and are noted in Sections 6, 7, 8, 9 and 10 of these proceedings. Comments made in the plenary sessions are also noted. Over the two day period, more than thirty hours (6 groups x 5 hours) of break-out group work had been summarized in a series of flip-charts. The group leaders presented summaries of this material in the final plenary sessions. This material forms the basis for much of the discussion in the remaining sections of this report.

Although we were most appreciative of their participation in the workshop, individual speakers commenting in either the question periods or plenary sessions have not been identified. As well, individuals are not named for their specific suggestions in the break-out work groups.

The members of **Group 1** are listed alphabetically below (please note that a full alphabetical listing of all workshop participants including their home office location can be found in Appendix A):

Barry Cole	FLW - Public Lands
Murray Doherty	FLW - Forest Service
Travis Ferguson	Alberta Environment
Heather Gerling	FLW - Public Lands
Perry Gerwing	Gulf Canada Resources Ltd.
Brian Hayward	Opinac Exploration Ltd.
Sandra Landsburg	NOVA Corporation
Gary Mott	Abandonment Recl. Tech. Ltd.
Bob Onciul	Alberta Environment
Ian Scott	Canadian Petroleum Association
Wayne Tedder	FLW - Public Lands
Bill Wolff	Bissett Resource Consultants Ltd.

An alphabetical listing of all **Group 2** members follows:

Barry Adams	FLW - Public Lands
Dan Blackmore	FLW - Public Lands
Dennis Cox	FLW - Forest Service
Klaus Exner	NOVA Corporation
John Hermans	Alberta Agriculture
John King	Alberta Environment
Kirby Lowen	Prairie Seeds Ltd.
Terry Macyk	Alberta Research Council
Bob Mahnic	Communiplan Inc.
Bruce Nesbitt	AEC Oil and Gas Co.

An alphabetical listing of all **Group 3** members follows:

George Benoit	FLW - Forest Service
Bill Fisher	Alberta Environment
Jeff Hartley	FLW - Public Lands
Len Knapik	Pedocan Land Evaluation Ltd.
Doug Knight	FLW - Public Lands
Albert Lees	NOVA Corporation
Mike Melnyk	Alberta Environment
Judith Smith	Concord Environmental
Glen Stalker	Can. West. Natural Gas Ltd.
Clare Tannas	East. Slopes Range. Cons.
John Ward	AMOCO Canada
Gary Warner	Encor Inc.

An alphabetical listing of all **Group 4** members follows:

Adolf Bruneski	FLW - Forest Service
Donna Dowell	North Canadian Oils Ltd.
Reinhart Dunse	Alberta Government Telephones
Al Fedkenheuer	NOVA Corporation
Arnold Janz	Alberta Environment
Duane Johnson	HBT Agra Ltd.
Al Malcolm	Alberta Environment
Craig Richardson	FLW - Public Lands
Kelly Scott	West. Oilfields Env. Services
Rob Staniland	BP Canada Inc.
Keith Stretch	FLW - Public Lands
David Walker	David Walker & Associates

An alphabetical listing of all **Group 5** members follows:

Diana Brierley	FLW - Public Lands
Jim Fairgrieve	FLW - Public Lands
Nancy Finlayson	Land Resources Network
Terry Forkheim	Norcen Energy Resources Ltd.
Karl Gilmore	TERA Env. Cons. Ltd.
David Lloyd	FLW - Public Lands
Lionel Peel	Alberta Government Telephones
Chris Powter	Alberta Environment
Gene Skappak	Renaissance Energy Ltd.
Howard Slavinski	Alberta Environment
Don Thompson	Petro-Canada

An alphabetical listing of all **Group 6** members follows:

Larry Brocke	Alberta Environment
Lowell Calder	FLW - Public Lands
Fred Kuipers	Pembina Corporation
Len Leskiw	Can Ag Enterprises Ltd.
Stuart Lunn	PanCanadian Petroleum Ltd.
Keith Lyseng	FLW - Public Lands
Blair McNeely	Alberta Environment
Doug Mead	Shell Canada Limited
Kirk Morrison	David Bromley Engineering Ltd.
John Toogood	Professor Emeritus
Mike Willoughby	FLW - Forest Service

6. BREAK-OUT SESSION: IDENTIFY SOIL PARAMETERS

The first break-out group assignment was to identify and rank the most important soil parameters for the measurement of pipeline reclamation success. Following the tabulation of the group responses is a review of comments and feedback presented in the plenary session. This section concludes with a brief summary of areas of significant group agreement or disagreement as indicated in the tabulated group responses.

The break-out groups employed the following procedural steps:

1. Brainstorm for key parameters--all suggestions were recorded on flip-charts over a 30 to 40 minute period (see Figure 5).

2. All parameters were identified on the basis of: What to measure? Why is it important? Where is it geographically applicable (province-wide, grassland, parkland, other)?

3. Using a flash-card system of nine consecutively numbered cards--one (1) was lowest and nine (9) was highest--each work group participant was asked to assign a rank value to their nine most important parameters. Group leaders/recorders tallied the number of participants supporting a particular parameter and the sum of all rank values.

4. Following the ranking of each of the identified parameters, the results were submitted to the workshop facilitator for a cumulative listing and ranking across all six break-out groups.

It was suggested that the groups examine the parameters on a province-wide basis, where possible. Where this would not be appropriate (for example, salinity might be considered as region-specific) the parameter should be identified as such. What was attempted in the ranking exercise was to try to weigh the significance of the identified soil and vegetation parameters. In giving direction to the

Figure 5. Sample Flip-Chart Format for Day 1 Break-Out Groups

	Proposed Soil/Vegetation Measurement Parameter	Number In Support	Total Score Value	Score Rank
1.	**What** to measure? **Why** is it important? **Where** applicable? - Province-wide - Grassland - Parkland - Other			
2.	What? Why? Where?			
3.	What? Why? Where?			
... n	What? Why? Where?			

group leaders/recorders, it was suggested they vote last--following the tally of all other group participants' votes.

6.1 TABULATION OF GROUP RESPONSES

Table 8 shows the results of the first break-out group assignment: identification and ranking of soil parameters. A total of 25 "unique" parameters were identified and ranked. All of these parameters were identified by the workshop break-out group participants. Each group started with a "blank-slate".

The rankings produced 11 soil parameters with values of 100 points or greater. There were five "top-ranked" soil parameters (over 200 points): topsoil depth (501 points), compaction (338 points), organic matter (299 points), erosion/soil stability (274 points), and texture (219 points). It should be noted that three groups ranked sodicity and salinity separately while three groups combined them. Sodicity scored 97 points alone, salinity scored 120 points alone and the combined salinity/sodicity score was 107 points. Given the split scores, salinity and/or sodicity may also have rated as one of the top-ranked soil parameters.

In examining the results on a group-by-group basis, there appears to be significant homogeneity between the groups. For example, all six groups identified topsoil depth as their highest ranking parameter. Compaction was ranked in the top four by all six groups. Organic matter was ranked in the top four by four groups. Erosion/soil stability was ranked in the top four by three groups.

Perhaps a more useful statistic can be constructed to evaluate the group scores. If we assume that each parameter can have a maximum flash-card value of "9" and that a "significant" value would be a score of 1/2 of the maximum value (in this case a "5")--the following "break-point" formula is suggested:

$$\text{Break-point} = \frac{\text{maximum \# of respondents in group} \times 9}{2}$$

An estimate of $\pm$10% error is also assumed.

By applying the "break-point" formula to the data in Table 8 we might better understand the dynamics of group selection. For example, topsoil depth was selected by all twelve Group 1 members as an important soil parameter. The sum of their rank scores was 105 points. By applying the "break-point" formula ($12 \times 9 / 2 = 54$) we arrive at a break-point of 54 with a 10% error variance of $\pm$ 5. So a value equal to or greater than 49 would indicate a "significant" parameter for Group 1. Table 8 shows all of the "significant" parameters, for each of the break-out session work groups.

By examining the "break-point" results, four soil parameters are shown to be significant: topsoil depth, compaction, organic matter and erosion/soil stability.

6.2 PLENARY SESSION COMMENTS AND SUMMARY

Dr. John Toogood presented the identified and ranked soil parameters in the afternoon plenary session of Day 1. Although workshop participants recognized that the ranking exercise was to be used as an "indicator" of group support, it was felt by some that perhaps the exercise was either "masking the real results" or the results had been negatively biased with the introduction of several "landscape" parameters into the ranking exercise.

In the soil parameter identification and ranking exercise, the parameters for recontouring/ surface drainage (ranked sixth), slope stability/ contour (ranked twenty-first), and roach height/ rutting (ranked twenty-third) were dismissed as landscape parameters and therefore invalid. An *ad hoc* group of soils experts convened at the end of the plenary session to re-group the identified soil parameters, excluding the previously noted landscape parameters.

It was also noted that the same problem had likely occurred in the vegetation parameter identification and ranking exercise. The concensus was that a second *ad hoc* group, this time of vegetation experts, would also re-group the "landscape-less" vegetation parameters. All workshop participants were asked to rank these new parameters by individual ballot. The ballots were collected prior to the commencement of the Day 2 activities, tabulated by the workshop facilitator, and new work group assignments scheduled.

Table 8. Identification and Ranking of Soils Parameters†

Ranking	Soil Parameters	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Totals
1.	Topsoil Depth	12/105*	8/59*	11/93*	12/88*	8/59*	11/97*	62/501*
2.	Compaction	12/66*	8/50*	11/54*	11/63*	8/38*	10/67*	60/338*
3.	Organic Matter	12/64*	8/42*	6/28	12/87*	6/29	9/49*	53/299*
4.	Erosion/Soil Stability	12/86*	6/24	9/58*	10/47	6/43*	3/16	46/274*
5.	Texture	11/42	7/48*	5/17	10/39	5/27	9/46*	47/219
6.	Recontour/Surface Drain.	11/40		10/31	11/36	8/21	3/11	43/139
7.	Topsoil/Subsoil Mixing			11/79*		8/42*		19/121
8.	Salinity	11/47				7/40*	8/33	26/120
9.	Structure			4/24	8/46	5/17	6/24	23/111
10.	Stoniness	10/21	5/12	5/17	8/23	3/14	4/21	35/108
11.	Salinity/Sodicity		6/32*	7/25	11/50*			24/107
12.	Sodicity	12/57*				2/6	8/34	22/97
13.	pH		5/28	4/6		5/22	6/29	20/85
14.	Fertility/Avail. Nutrients	5/17		5/23	2/5	1/6	6/30	19/81
15.	Tilth		5/26	2/12				7/38
16.	Contaminants			3/14	6/22			9/36
17.	Infiltration/Permeability		7/24					7/24
18.	Calcareousness/Lime		4/7		3/8		2/6	9/21
19.	Soil Moisture					3/18		3/18
20.	Layering				5/17			5/17
21.	Slope/Contour					2/12		2/12
22.	Subsidence					2/11		2/11
23.	Roaching/Rutting					2/7		2/7
24.	Depth of Rooting			3/6				3/6
25.	Water Holding Capacity						1/2	1/2
	Break-Point Range Scores	**54±5**	**36±4**	**50±5**	**54±4**	**36±4**	**50±5**	**279±28**

† Note that the first number indicates the total participants that gave a ranking to the parameter. The second number indicates the sum total of all rank values for the parameter.

* Denotes greater than break-point range score

7. BREAK-OUT SESSION: IDENTIFY VEGETATION PARAMETERS

The second series of break-out group sessions identified and ranked the most important vegetation parameters for the measurement of pipeline reclamation success. The parameter identification and ranking procedure is noted in Section 6 of these proceedings.

7.1 TABULATION OF GROUP RESPONSES

Table 9 shows the results of the second break-out group assignment: identification and ranking of vegetation parameters. A total of 26 "unique" vegetation parameters were identified and ranked. As was the case for the soils ranking exercise, each work group started with a "blank-slate".

The rankings produced 9 vegetation parameters with values of 100 points or greater. There were four "top-ranked" vegetation parameters (over 200 points): ground cover (462 points), plant density (433 points), diversity/species (349 points) and yield/productivity (317 points).

In examining the results on a group-by-group basis, there appears (as was the case with the soil parameters) to be significant homogeneity between the groups. For example, ground cover and plant density was ranked in the top four by all six groups. Diversity of species and yield/ productivity was ranked in the top six by five of the break-out groups.

As was suggested in Section 6.1, a "break-point" formula was applied to the vegetation data in Table 9. Examination of the "break-point" results reveals the following four vegetation parameters to be significant: ground cover, plant density, diversity/species composition, and yield/productivity, all of which have break-point scores exceeding the critical value of 234 ($\pm$10% error).

7.2 PLENARY SESSION COMMENTS AND SUMMARY

Mr. Bob Mahnic presented the identified and ranked vegetation parameters in the afternoon plenary session of Day 1. As has been noted in Section 6.2, the discussion was mostly concerned with the introduction of several "landscape" parameters into the ranking exercise.

In the vegetation parameter identification and ranking exercise, the parameters for land use capability (ranked tenth), land management (ranked twenty-first), and reclamation plan compliance (ranked twenty-fourth) were dismissed as landscape parameters and therefore invalid. The results of the re-ranking exercise are discussed in Section 8.

Table 9. Identification and Ranking of Vegetation Parameters†

Ranking	Vegetation Parameters	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Totals
1.	Ground Cover	12/87*	8/50*	12/77*	12/97*	9/74*	10/77*	63/462*
2.	Plant Density	12/66*	8/63*	12/79*	12/95*	9/56*	10/74*	63/433*
3.	Diversity/Species	12/70*	8/61*	12/77*	12/60*		10/81*	54/349*
4.	Yield/Productivity	12/61*	8/43*	11/43	12/55*	9/53*	10/62*	62/317*
5.	Sustainability	12/73*	7/44*	11/48				30/165
6.	Suitability/Palatability	12/65*	5/9			9/61*		26/135
7.	Rooting Pattern/Char.	12/42	7/25	10/37			6/17	35/121
8.	Composition				12/74*	9/44*		21/118
9.	Vigor/Phenology			7/25	7/19	9/34	8/28	31/106
10.	Land Use Compatability			11/53*		6/28		17/81
11.	Health/Nutrient Req'ts.	12/56*	4/11					16/67
12.	Biomass/Litter					9/33	7/22	16/55
13.	Establishment			10/55*				10/55
14.	Weed Introduction		8/25				8/29	16/54
15.	Plant Vigour				11/52			11/52
16.	Aesthetic Match			4/10		8/20	7/22	19/52
17.	Weed Density				12/43			12/43
18.	Root/Shoot Ratio				9/28			9/28
19.	Persistence						7/20	7/20
20.	Encroachment/off ROW						5/16	5/16
21.	Land Management			6/16				6/16
22.	Rooting Depth		6/16					6/16
23.	Nitrogen Fixation		3/13					3/13
24.	Reclamation Plan Comp.			2/12				2/12
25.	Stocking Density				6/12			6/12
26.	Animal Performance				3/5			3/5
	Break-Point Range Scores	**54±5**	**36±4**	**54±5**	**54±5**	**41±4**	**45±5**	**234±23**

† Note that the first number indicates the total participants that gave a ranking to the parameter. The second number indicates the sum total of all rank values for the parameter.

* Denotes greater than break-point range score

8. POST-PLENARY RE-ASSESSMENT OF PARAMETERS

As noted in Sections 6 and 7, identified soil and vegetation parameters were re-grouped and re-ranked by workshop participants prior to the commencement of Day 2 activities. Fifty-seven (57) re-ranked soil and vegetation parameter surveys were completed. The re-assessed soils and vegetation parameters are shown in Tables 10 and 11, respectively. The break-point values were calculated according to the methodology and formula presented in Section 6.1.

8.1 RE-ASSESSMENT OF SOIL AND VEGETATION PARAMETERS

The soil parameters identified after the re-assessment were: surface stones and gravel; erosion protection; soil loss by erosion; topsoil replacement thickness; topsoil admixing (including organic matter); compaction (including density, infiltration, permeability, penetration resistance and structure); salinity; sodicity; pH and lime; texture (including coarse fragments); available and total nutrients; and, contaminants (see Table 10).

Table 10 shows that seven soil parameters had high rank scores (more than 300 points). These included, in rank order: topsoil admixing; topsoil replacement thickness; compaction; soil loss by erosion; texture; salinity; and erosion protection. All of these parameters, except erosion protection, exceeded the critical break-point range value.

The vegetation parameters identified after the re-assessment were: plant density and yield; vigour (including health requirements and phenology); ground cover (including litter and biomass); species composition (including sustainability, species suitability, palatability, aesthetic match and persistance); rooting characteristics (including rooting pattern and depth); weeds and undesirables (including weed introductions, weed density, and off right-of-way encroachment); and, woody stocking density (including wildlife habitat, forestry, shelter belt density) (see Table 11).

The plant density and yield/productivity parameters should have been separate items in this ranking exercise. An oversight caused the parameter to inadvertently be combined with plant density. The break-out group handling plant density was asked to treat them as individual parameters. The original rankings on Day 1 indicated both plant density and yield to be significant parameters.

Table 11 shows that five vegetation parameters had high rank scores (more than 200 points). These included, in rank order: plant density and yield/productivity; species composition; ground cover; and plant vigour. All of these parameters exceeded the critical break-point score.

It was decided by the Workshop Steering Committee that it would be useful to have each of the six break-out groups discuss one soil and one vegetation parameter in the Day 2 work group sessions. As a result, the top six soil parameters (on the basis of rank score values noted in Table 10) and the top six vegetation parameters (on the basis of rank score values noted in Table 11) were assigned to the work groups.

Two work group exercises were completed on Day 2. First, about 40 to 50 minutes was used to discuss the how, where, when, of each of the assigned parameters. A flip chart presentation was completed by work group representatives during the Day 2 plenary sessions. Work group representatives also were given the task to act as discussants to the presentations, to indicate either gaps in the analysis or to provide additional suggestions.

Table 10. Re-Grouped Soil Parameter Rankings

Ranking	Soil Parameters	Rank Scores	Presentation #
1	Topsoil Admixing (O.M., colour, tilth)	557*	1
2	Topsoil Replacement Thickness	531*	2
3	Compaction (density, infiltration, permeability, etc.)	439*	3
4	Soil Loss by Erosion	394*	4
5	Texture (including coarse fragments)	384*	5
6	Salinity	370*	6
7	Erosion Protection (straw, mulch, tackifiers, etc.)	325	N/A
8	Surface Stones and Gravel	294	N/A
9	Sodicity	286	N/A
10	Available and Total Nutrients	252	N/A
11	pH and Lime	251	N/A
12	Contaminants	110	N/A
	Break-Point Range Score	**392±39**	

* Denotes greater than break-point range score

Table 11 Re-Grouped Vegetation Parameter Rankings

Ranking	Vegetation Parameter	Rank Scores	Presentation #
1	Plant Density (yield/productivity)	334*	7
2	Species Composition (sustainability, suitability, etc.)	321*	8
3	Ground Cover (litter, biomass)	303*	9
4	Vigour (health, nutrient requirements, phenology)	220*	10
5	Weeds/Undesirables (off-ROW encroachment, etc.)	162	11
6	Rooting Characteristics (rooting pattern and depth)	146	12
7	Woody Stocking Density (wildlife habitat, etc.)	108	N/A
	Break-Point Range Score	**200±20**	

* Denotes greater than break-point range score

8.2 QUESTION PERIOD

(Plenary Session responses provided by Mr. David Lloyd, AFLW, Edmonton and Mr. Chris Powter, Alberta Environment, Edmonton)

Question #1. Can you explain how much detail we're to go into when we're looking at the "how" of implementing the parameters?

Answer #1. I think it's up to the group that's going to do the parameter to decide on the level of detail. Obviously, it should be field applicable or measurable but to enough detail so that we can get some degree of satisfaction that that measure is reasonably good. I'd like to leave it up to the group and their innovativeness.

Question #2. On salinity and sodicity--is there any possibility that those who are discussing work assignment #5 combine those two for discussion?

Answer #2 No. We have gone through this before. We will not combine any more parameters.

Question #3. For the soil parameters--topsoil admixing--what do you measure? Organic matter? Colour? Tilth?

Answer #3. We suggested look at colour as a reflection of organic matter. For compaction, we felt that perhaps penetration resistance should be examined.

Question #4. Do you want us to go into details with regard to what standards we would use or whether or not we should compare on right-of-way or off right-of-way?

Answer #4. No standards are to be discussed for this workshop. On and off right-of-way comparisons are allowed.

Question #5. Can you give us some more guidance--do you want it broken down by Green Area, White Area, forest, grasses, agricultural?

Answer #5. No. If possible, keep it general to the province as a whole.

Question #6. Would you like a quantitative as opposed to qualitative assessment?

Answer #6. I would, but that's up to each of the work groups. Quantitative assessments are easier to deal with if there's a dispute. Qualitative assessment are more subjective.

9. PLENARY SESSION: "SELECT" SOIL PARAMETERS

The Day 2 break-out sessions examined the following six "select" soil parameters: topsoil admixing, topsoil replacement thickness, compaction, soil loss by erosion, texture, and salinity. For each parameter the groups suggested how the parameter should be measured, where it should be measured (on or off right-of-way, etc.), and when. Each of the six break-out groups assigned one member to present the soil parameter assigned to their group. A member of a different group was asked to lead the discussion. The Day 2 plenary sessions were moderated by Dr. John Toogood.

The soil parameter information was presented with the aid of flip-chart materials produced by each of the break-out groups. The break-out groups had been asked on Day 1 to consider why each soil or vegetation parameter was important. The reasons for their selection were not tabulated on the flip-charts prepared but presumably were that these particular parameters would give the best indication of the success or failure of reclamation. The flip-chart information is reproduced below for each parameter. As well, relevant comments made by the discussant follow the presentation material.

9.1 TOPSOIL ADMIXING

(Presenter Group 3 - Mr. Len Knapik, Pedocan Land Evaluation Ltd., Edmonton)

How

Color
- Munsell Chart
- Uniformity - % mixing
- Surface and cross-section

Vegetative Cover
- Patchy
- Species
- Phenology (management)

Texture
- Field

Non-Homogeneity
- Lumps and Layers

Consistence
- Field

Carbonates
- Acid

Organic Matter
- Visual

Where

- Total description rather than sampling approach.
- Drive over or aerial survey first. "Eyeball" and infra-red photos to provide vegetation clues.
- Selective sampling:
  1. Dig holes in both good and bad areas;
  2. Check by soil type; and,
  3. Sample spoil, trench, work and off right-of-way sites.

When

- After clean-up in all situations.
- After vegetation/crop establishment--generally 1 to 2 years.
- Construction quality control is very important.

(Discussant Group 6 - Mr. Len Leskiw, Can Ag Enterprises, Edmonton)

I'd just like to say two things. One is that Group 3 appears to be getting into criteria and standards. Our group did not talk about standards. We assume there are criteria and I guess we're just talking about how to determine whether you've made or failed criteria. So to keep things short, we didn't get into discussing the relevant merits or different considerations per criterion.

The other comment I was going to make was that it was implied that you should concentrate on problem areas. I think there's a problem with just doing problem areas. You have to do some descriptive work to make yourself confident that that is in fact what's causing your problem in your problem area. I would support Group 3 saying that you have do to some considered confirmation around your problem areas.

When looking at a problem area look at what's adjacent to it. What we were trying to steer away from was having to do the whole 20 km if we know that there are problems in 20 to 30 m sections. It could be hillsides . . . it could be crossings . . . We don't have to spend a lot of time doing a complete inventory of the whole stretch of right-of way. We need to tailor the analysis to be practical and economical. Minimize not maximize the amount of work needed.

Question #1. It may be an obvious manifestation you're picking up in your first "eyeball" or ocular survey without any detail. You're taking a big risk assuming that the very gross assessment we're doing has in fact been identified as a real problem area. The efficiencies of that will vary depending on whether there is a crop or stand of grass.

Answer #1. (None given.)

Question #2. I'm wondering if you're largely basing this on colour and texture--what do you do when the ground/soil is wet and you've got no texture difference between topsoil and subsoil?

Answer #2. You will get situations where you have no colour difference and you've got situations where you have no texture difference. One of the things you can look at there is what was your stated goal. How many centimetres of topsoil were you replacing? That's why we had more than one category--colour, texture, organic matter.

9.2 TOPSOIL REPLACEMENT THICKNESS

(Presenter Group 2 - Mr. Dennis Cox, AFLW - Forest Services, Edson)

Assumption: to replace the topsoil at a level equal to that which was there prior to disturbance.

How

- Shovel, etc.
- Measuring tool--ruler, etc.

Where

- Cross-section of stripping width on right-of-way (minimum of 3 measurements across stripped area and 1 control adjacent to ROW).
- Thickness can be compared to:
  1. adjacent topsoil off right-of-way; and,
  2. soil survey of area, if available.
- No criteria provided for number of measurements along pipeline route, however, recommended that:
  1. specific attention be paid to areas where topographic differences occur resulting in potential for erosion; and,
  2. in areas of widely variable (over short distance) soils such as Chernozemic/Solonetzic that replaced thickness will be a mean depth representing the soil units.

When

- As soon as possible upon construction completion/clean-up by company/contractor. Recognize that regulators may not be able to complete field measurements for up to 1 year after construction.
- At time of certification, additional measurements may be done if required. Recognize that this is a measure of "topsoil thickness" rather than "replaced thickness".

(Discussant Group 5 - Mr. Chris Powter, Alberta Environment, Edmonton)

I'll just highlight some differences. In some instances you don't take off all the topsoil or there may be a difference in interpretation of what topsoil is. Need to look at assessing compliance with the required depth of topsoil replacement. We noted that where there is no topsoil salvage, for example in minimum disturbance areas, there's no point in taking any measurement. We felt that it's more important to sample more frequently in areas of thin topsoil because those are the areas where you can't afford to lose very much. In areas where the topsoil is thicker, you may be able to afford greater loss and so there may not be a need for such frequent measurement.

We suggested using a core as a sampling tool rather than a shovel--it's quicker and easier. We agreed with the site locations. We suggested using a transect with the 4 points, but using 2 transects per location when sampling. Specific areas to be assessed include road crossings, hilltops, slopes, side bends and problem areas identified in construction reports. We also suggested a minimum sampling density of 2 sites per kilometre. We weren't sure whether the sampling should be random or based on a grid. In addition to sampling immediately after topsoil replacement, we also suggest that you sample any time after repairs.

We're debating whether those two sites per kilometre should include problem areas that were identified or whether they shouldn't. We finally decided to do the two plus any problem areas which include side bends and those kinds of things.

Question #1. Why wouldn't you take all the topsoil?

Answer #1. From discussions we had yesterday, when we were putting together the list of parameters, it was noted that there are sometimes agreements that if you have very deep topsoil on the right-of-way you don't have to salvage it all. Therefore, if you're collecting the data to compare, you can't say that I only have 40 or 50 cm here and I haven't met my target of 80 cm which is what may be measured in the natural area. That wasn't what you were required to salvage.

9.3 COMPACTION

(Presenter Group 4 - Mr. Al Fedkenheuer, NOVA Corporation, Calgary)

How

- Stepwise Approach
- Step 1 (Level 1): Ocular
  - plant growth
  - ponding
  - rutting
- Step 2 (Level 2): Penetrometer
  - centre cone
  - screwdriver (Phillips)
- Step 3 (Level 3): Dig hole
  - structure
  - root distribution
  - cup and scale
  - nuclear densometer

Where

- Workside (problem sites).
- High traffic areas.

When

- After 1 full growing season.
- Late in season.

(Discussant Group 3 - Mr. Mike Melnyk, Alberta Environment, Calgary)

Our group felt that the entire right-of-way should be examined immediately after clean-up and following the first growing season. Rooting and soil strength should be observed for any problems.

It might also be necessary to check for undercompaction of the soils. The use of new technologies such as ground radar should be considered. Measurements of bulk density could be made using moisture content or other bulk density measurements.

It is also important to maintain good quality control during construction, ensuring a quality clean-up job. Step 2 or 3 of your proposal may be desirable in cases of line abandonment to ensure there are no future problems.

Question #1. You mentioned that you had used the visual method first before any vegetation is established. Isn't it pretty easy to mask compaction? How would you tell?

Answer #1 We had gone for this one--the confirmatory work--if you recall. I think on the vegetation one--in terms of "where"--we concentrated on the high hazard-high traffic stuff but it was confirmatory work again.

Question #2. I was just wondering and maybe I missed it but why wouldn't you check compaction during cleanup? That is the very time when you can do something about it.

Answer #2. I think we did mention that in our group that it would be part of the ongoing quality control of your pipeline. We excluded that by saying that quality control should be there all the time. I guess another reason for our thinking is because you do sometimes see it right away but after a full growing season you don't see it anymore. We were trying to take that into account so that you're not out there thinking that you've got a problem and going and doing a lot of work that may not be necessary.

9.4 SOIL LOSS BY EROSION

(Presenter Group 1 - Mr. Travis Ferguson, Alberta Environment, Edmonton)

Assumptions - two levels of soil loss evaluation:

1. overall screening; and,
2. site specific evaluation.

9.4.1 Soil Loss by Wind Erosion

How

- Measure topsoil depth and % organic matter (via colour).
- Tonnes/hectare loss of organic matter (soil displacement, soil loss on-site, soil loss during construction).
- Composite (3 to 5) samples at 10 m to 15 m intervals.
- Steps:
  1. Depth/volume;
  2. Organic matter content--monitoring (proactive, reactive); and,
  3. Lab analysis for % organic matter.

Where

- Sample sites: control, spoil, trench, and workside.
- Sample same soil series.

When

- When erosion is visible.

9.4.2 Soil Loss by Water/Topography Erosion

How

- Topsoil and subsoil depth correlated with % organic matter.
- Representative number of measurement sites.
- Monitor using stakes.

Where

- Control versus on-ROW problem area (trench, spoil, work side).

When

- Visible rills, gullies, depositional features are observed.

(Discussant Group 4 - Dr. David Walker, David Walker & Associates, Calgary)

Our group also felt that the first round assessment of soil loss should be a multi-tiered evaluation. The first evaluation could be an ocular evaluation in which presence of erosion could be identified by a number of inferential techniques such as deposition or the presence/absence of rills. Once a site is identified as being subject to erosion, we might suggest that perhaps the quantity of soil loss measurement could be used. That might also suggest some sort of mitigation. Beyond that--measuring soil loss--there was some serious disagreement between both sides. There are more stringent ways of measuring soil loss by pins or sediment collection. We didn't suggest measuring off right-of-way and doing a comparison of on and off right-of-way.

9.5 TEXTURE

(Presenter Group 6 - Mr. Larry Brocke, Alberta Environment, Edmonton)

How

- Lab-testing or hand-testing--depends on purpose.
  - Baseline: lab to calibrate or hand-testing
  - Quality control - hand-testing
  - Problem areas - lab test

Where

- After trenching to verify material handling, plan implementation.
- Work side/spoil side to assess effect of construction activity.
- Off right-of-way for relative comparision.

When

- Before construction.
- During construction.
- After construction.

(Discussant Group 1 - Mr. Wayne Tedder, AFLW-Public Lands, Edmonton)

We would agree with your group's evaluation that hand-testing for texture is an appropriate measurement if done satisfactorily. In more controversial areas, lab testing would be preferred.

Question #1. I can't help but refer to my study of manual texturing. In the early 1960s I worked with a group of soil surveyors at the University of Alberta. We did manual texturing of some samples on which we had done particle size analysis--so we knew precisely what the soil texture was. It became evident that many experienced soil surveyors who were doing manual texturing every day out in the field could not estimate precisely what percentage of clay and what percentage of sand were in the samples. They were quite often calling a loam a sandy loam and calling a clay a silty clay, etc. In other words, we didn't find manual texturing to be a precise measurement.

Answer #1. I'd like to challenge that statement. A point of clarification--there's a difference between estimating 20% and 22% sand as against comparing a silt loam to a clay loam and what we're talking about here is comparing silt loam to clay loam.

9.6 SALINITY

(Presenter Group 5 - Ms. Nancy Finlayson, Land Resources Network, Edmonton)

Assumptions

- All right-of-way to be visually inspected, on ground.

- Meter is OK for rough values and comparing on and off right-of-way.
- Assume basic training in identifying salts in field, use of EC meter, recognition of salt tolerant species, and plant response to salinity.
- Sample locations for field EC should be representative of saline area, appropriate for area sample.
- If salts are present on right-of-way in excess of off right-of-way, you have a problem--damage control is needed.
- In areas with visual clues of sodicity, or if indicated on soil survey, lab test for sodicity.
- Any EC samples to lab should have SAR done as well if sodicity is suspected.

How

- Soil survey maps
  - Use aerial photos to stratify line.
  - Field construction notes from environmental inspectors, etc.
- Visually
  - Soil - crystals, colour (and/or taste).
  - Plant response (indicator plants, vigour).
- EC Meter
  - 2:1 (portable meter)
  - Requires 2:1 meter, distilled water, beaker, scoops and wash water.
  - To compare on/off right-of-way, rather than absolute measure.
  - No composite samples--use discrete samples.
- Lab EC
  - Saturated Paste
  - For problem resolution (no composites, get SAR as well).

Where

- Soil Survey: Wherever available - air photos.
- Visual
  - full length of right-of-way.
  - topsoil and root zone (i.e., 50 cm).
  - on/off right-of-way, both soils and vegetation.
  - cross right-of-way and off right-of-way control.
  - frequency based on soil survey and visual signs of problems.
- Meter: wherever problems are identified in 1 or 2 above - topsoil and root zone (i.e., 50 cm).

When

- Soil Survey
  - before field inspection.
- Visual
  - Right after construction (do soils on and off right-of-way; vegetation off right-of-way only).
  - One full growing season after vegetation established in midsummer (June/July) for vegetation and soils. May require compensation for crop damages.
- Portable EC
  - Whenever salinity encountered with visual inspection. Either do on-site (ideal) or take samples for same-day analysis. (Post-construction inspection or after one growing season).
- Lab
  - For litigation, controversial situations.

(Discussant Group 2 - Mr. John Hermans, Alberta Agriculture, Edmonton)

Your group seems to have covered the main areas. One thing that should be considered, from the cost/benefit perspective, is how selective should we be? With respect to field measurements, samples should be taken vertically--recharge/discharge. Finally, it may be necessary to continue inspection for problems on an ongoing basis. How often? Perhaps yearly. Colour could be used as a visual indication of where there may be problems. We share your concern that the revegetation effort be successful.

Question #1. I know it was just touched on a little bit but I would like to say something about the time factor. It was interesting to me that you ended up with sampling 1 year after. Did you have much discussion about using a longer time period or how did you end up with the one year? I would have, personally, probably made it a longer time period.

Answer #1. We felt that at that point problems would be showing up in the vegetation if there were problems and that that was one point where you would be able to identify your problem areas and carry on with the rest of the examination.

Answer #1a. I think we also said that once you've identified a problem area that you're in another kind of realm where you're dealing with problem resolution and fixing something so it comes out of the reclamation assessment and it goes on to longer term interaction with the company or the landowner.

Question #2. Well that's where my question is. I would think you would pick up your potential areas off of your soil surveys and then delay it. I would have probably delayed it till Year 3 or something like that. I'm making the assumption based on some of the observations that I have made.

Answer #2. One consideration would be that if you have a problem and you're not getting revegetation, you're going to want to know that before Year 3.

Answer #2a. Both the pipeline company and the landowner has a stake in wanting to revegetate so I think there's an equal concern there.

Question #3. In regard to sampling the full length of the line--we already have our D & R so you already have that information available to you. I'm wondering why you would want to do it this way?

Answer #3. Maybe I didn't say it, but what we meant was you should complete a visual examination of the whole line for problems. You would do the more specific sampling on areas that are already indicated as potential problems or as a problem. So we're not advocating that you go out with your EC meter and randomly sample every kilometre. The problem there is that even if you use the best of soil surveys, you can still get patches of salts that don't come up at that scale but could still cause problems.

10. PLENARY SESSION: "SELECT" VEGETATION PARAMETERS

The Day 2 break-out sessions examined the following seven "select" vegetation parameters: plant density, yield/productivity, plant vigour, ground cover, species composition, rooting characteristics, and weeds. For each parameter the groups suggested how the parameter should be measured, where it should be measured (on or off right-of-way, etc.), and when. Each break-out group assigned one member to present the vegetation parameter assigned to their group. Another group provided a discussant. The Day 2 plenary sessions were moderated by Dr. John Toogood.

The vegetation parameter information was presented with the aid of flip-chart materials produced by each of the break-out groups. As with the soil parameters the reasons for selecting these vegetation parameters were discussed on Day 1 but are not given here. The information is reproduced below for each parameter. As well, relevant comments made by the discussant follow the presentation material.

10.1 PLANT DENSITY

(***Presenter Group 6 - Mr. Stuart Lunn, PanCanadian Petroleum, Calgary***)

How

- Ocular
- 10 plants/m^2 on level or more on erosion prone areas
- Using random sample or transect

Where

- At visually perceived problem areas
- On, along, and off trench and/or off right-of-way (after 3 years).

When

- After one growing season
- Problem area driven

(***Discussant Group 1 - Ms. Heather Gerling, AFLW-Public Lands, Edmonton***)

We would agree that that the first assessment of plant density should be an ocular assessment and that this should be done sometime following germination but prior to establishment of the seed. Problem areas can be assessed using representative sampling. Our group felt that assessments should be conducted annually.

Question #1. Just to add to the comment made in the Group 6 presentation regarding the plants per unit area. That's a standard. Perhaps I'd suggest just do a stem count per unit area, the standard to be determined at some point but agreed that we should do a stem count per unit area.

Answer #1. I was in that group and I think we just stated that it was something that was brought up earlier. I don't think we actually decided on a standard.

Question #2. You said you'd use the ocular method first and then if necessary some plot frames. Where is the cutoff point to go to using plot frames?

Answer #2. There was no consensus reached in the group.

Answer #2a. I would argue that you don't really need to do it where you've got lots of things growing and you don't really need to do it when you have nothing growing. Use the plot frames only in the ones that are problematic--when you're not sure.

Answer #2b. I think you would want somebody who is an experienced environmental inspector rather than a contractor making the evaluation. They should have the

experience to relate density fairly and properly.

Answer #2c. I think it has to be decided--Are you going to do the whole pipeline right-of-way? We haven't decided that. Are you going to do problem areas, only? We don't have a standard to do it. Right now from a practical point of view, I don't think we should do the whole pipeline. From a forester's perspective, we don't have the time to conduct plots of the whole pipeline.

Answer #2d. There probably is going to be a criterion for any given section of line and you're going to have to determine whether you've met that criterion or not. When you walk on the right-of-way you can probably tell visually whether its questionable or not. It's either dead, fully grown or somewhere in between. If it's questionable, you have to have some numbers to quantify the problem. Presumably if you have to meet a standard, there has to be an inspection.

10.2 YIELD/PRODUCTIVITY

(Presenter Group 6 - Mr. Stuart Lunn, PanCanadian Petroleum, Calgary)

How

- Measure green and/or dry weight.

Where

- Cultivated lands.

When

- End of growing season.

(Discussant Group 1 - Ms. Heather Gerling, AFLW-Public Lands, Edmonton)

With regard to yield/productivity, our group felt that an ocular assessment would be necessary. This should help to determine the cause of the problem. Site sampling in problem areas would follow.

10.3 SPECIES COMPOSITION

(Presenter Group 3 - Mr. Albert Lees, NOVA Corporation, Calgary)

How

- Ocular Assessment:
  1. General assessment along entire line for vegetation re-establishment (aerial or ground).
  2. Daubenmire mid-point (% cover native species, undesirables, seedlings, agronomic species, litter, persistence, encroachment, vigor, diversity).
  3. Point frame.
  4. Line intercept.
  5. Plotless estimate % cover.
  6. Biomass (with Daubenmire frame).
- Photographic record (aerial, on ground, videos, stills).

Where

- All assessments across right-of-way (spoil, trench, work side).
- General assessment total length of pipeline.
- Detailed assessment--stratified by vegetation types, site type and land management.

When

- End of first growing season (August - to allow for reseeding) - general assessment.
- Annual assessment to end of life of project--general assessment.
- Detailed assessment 2 to 3 years after reclamation plan in place.
- When is subject to land management objectives.

(***Discussant Group 6 - Mr. Mike Willoughby, AFLW-Forest Service, Edmonton***)

Some emphasis should be made on the basis of objectives relating to a particular species. First, we need to establish the standards and timing. When will the measurements take place? What are the success criteria? What are the composition criteria? Criteria need to be established and then sampling is possible.

10. 4 GROUND COVER
(***Presenter Group 4 - Dr. David Walker, David Walker & Associates, Calgary***)

How

- Visual observation.
- Measure:
  - cover estimate categories, quadrat (range assessment method)
  - line intercept
  - point frame/optical cover
  - photographic quadrat
  - aerial/laser, remote sensing, color infrared.

When

- Two or more growing seasons.

Where

- Entire right-of-way (off right-of-way control sites for criteria).

(***Discussant Group 3 - Ms. Judy Smith, Concord Environmental, Calgary***)

Our group felt that a 3-tiered system for measuring ground cover would be more beneficial than a 2-tiered approach. Tier 1 would be a screening assessment of the entire right-of-way, concentrating on locating problem areas right after construction and clean-up. Screening would be at the end of first growing season, and annually thereafter.

Tier 2 would be a detailed assessment in problem areas, and could be undertaken in any year. Again, review conditions along the entire right-of-way 2 to 3 years after clean-up. Detailed assessments at three sites across the right-of-way.

Tier 3 would be a general assessment, and should be conducted once a year until cover is full-grown. Following clean-up, erosion should be measured to ensure that controlling methods are in place and are working.

Question #1. Could you clarify how many inspections you are expecting to be done to do what you are talking about?

Answer #1. For the general assessment--which is driving along the right-of-way and just trying to identify problem areas--we recommend one each year, at least until you get full ground cover.

Question #2. I'm afraid I'm going to have to also disagree. You can't read cover obliquely. So you're either going to go and walk or fly the entire line every year. Is that what you're suggesting to look for the problem spots?

Answer #2. That's what we've suggested.

Question #3. That's a criterion. In the first place you're going to have to be vertical over the right-of-way to even assess it. You can't do it from the roadside and you can't do it from off right-of-way. I think how many times it should be done should be really dependent on where it is in relation with last year's conditions and the results of the first soil survey. So I think that's a criterion after the initial measurements. Comments?

Answer #3. Basically what we were saying is that any kind of assessment procedure would be reviewed based on discussions with the regulatory agencies. If erosion control is your primary measurement, definitely you would be taking a look at that line every year until you have adequate ground cover to solve that erosion problem and that might be one assessment until you've got it or it might be two assessments.

Question #4. Did I misunderstand you or did you say that you would assess ground cover right after clean-up?

Answer #4. That came up in our group as an item for discussion. What we suggested was after cleanup it is important to ensure that areas that may be susceptible to erosion have proper cover--whether it be mulching or grubbing or whatever form of erosion control that is utilized. It is more a measure to make sure that the erosion controlling methods are in place right after cleanup.

Question #5. This (ground cover) is the most important parameter for erosion control and I just question the inference of one presentation that the higher the density of plants means the better the erosion control. The answer to that is no.

10.5 PLANT VIGOUR

(Presenter Group 2 - Ms. Diana Brierly, AFLW-Public Lands, Edmonton)

Assumptions

- All comparisons are on versus off right-of-way.
- All comparisons are visual, qualitative.
- Done by trained personnel.
- Flag to detect other problems (bioassay).

How

- Visual assessment of plant:
  - height
  - colour
  - disease/insects
  - robustness
  - form/shape/abnormalities
- Send samples to lab for diagnosis/prognosis in problem situations.

Where

- Full right-of-way, on/off comparisions - full length of right-of-way.

When

- Mid-summer after first full successful growing season.
- Mid-summer after third full successful growing season.
- Wherever possible, tie to plant density and composition assessments. Also, can be ongoing, whenever on line.

(Discussant Group 2 - Mr. Kirby Lowen, Prairie Seeds, Edmonton)

We would agree with much of your proposal. The on/off right-of-way comparison is not an absolute but that would be valuable information to measure. You could have different forms of species and you obviously have different stands so there would be some circumstances where it might not be appropriate.

Question #1. Why would you send the plants to the lab rather than sending a soil sample to find out if there's something wrong with the soil? I think you're just going half way by only sending a plant sample.

Answer #1. Well, we wouldn't know if it was necessarily a plant problem--if it was a plant disease.

10.6 WEEDS

(Presenter Group 1 - Mr. Bill Wolff, Bissett Resource Consultants, Calgary)

How

- Noxious (presence or absence)--right-of-way versus control.
- Check seed certification tag for weed introduction.
- Undesirable: determine density or ground cover (right-of-way versus control) depending on species.
- Undesirable species: not noxious.

Density:
- stem count using grid
- compare to off right-of-way
- statistics
- random plots.

Ground or Canopy Cover:
- 2-D grid
- % area
- compare to off right-of-way
- statistics
- random plots.
- Check entire right-of-way if noxious weeds present.
- Control vs. problem area.

When

- Visible recognition of problem
- Preflower stage for identification--control in May, June (foothills).
- Control prior to setting pods preferred but pick and burn anytime for some species.

Where

- Definition of Undesirable: any species including weeds, grasses, etc. that are not consistent with the land use.

(Discussant Group 4 - Mr. Rob Staniland, BP Canada, Calgary)

We would be in agreement with much of your proposal. However, weeds should be assessed soon enough to institute control methods, if they are required.

Question #1. I don't know why the weeds have to be picked and burned? I think weeds can be controlled with management more than anything else. Especially if someone has a deemed weed problem and they are asked to pick and burn these things. The other thing to note is that certificates are not on the bag. On certified seed there are blue tags that indicate a certified seed but there is no indication of weeds. I would suggest that anyone that is going into seeding a pipeline, have your seed mix analyzed for purity which means what weed seeds are in there and then they have a record. It will not be on the bag, it will be on a piece of paper from a recognized lab of what weeds are in that mix and what the purity is.

Question #2. I think Registered Seed Growers may spray their fields but from time to time they may go in and pick rather than spray the whole field again.

Answer #2. Again, the control practice will be specific to the circumstance of the land use.

10.7 ROOTING CHARACTERISTICS

(Presenter Group 2 - Mr. Kirby Lowen, Prairie Seeds, Edmonton)

Why

- Diagnosis of problem - not routine measurement.

How

- Excavation:
  - observation *in situ*
  - removal for further investigation if deemed necessary.

Where

- On right-of-way where visual problem evident - compare to adjacent off right-of-way (same species).

When

- When visual problem is evident (in time).
- Likely measured after a number of other parameters (salinity, contamination, pH, physical characteristics) have been assessed. Rooting characteristics are a function of soil and other factors.

(***Discussant Group 5 - Mr. Chris Powter, Alberta Environment, Edmonton***)

I would suggest that our group would agree to much of your assessment of the problem. Perhaps an additional measure would be to indicate sustainability. This would require trained personnel for a field assessment, however. As well, you might consider the use of photos to identify and assess problem areas. The root/shoot ratio is another good yardstick for measuring this parameter.

10.8 GENERAL QUESTIONS ON SOIL AND VEGETATION PARAMETERS

Mr. Len Leskiw, of Can Ag Enterprises Ltd., raised five issues which he felt had not received adequate attention at this workshop and should be considered in further studies of reclamation assessments. These were as follows:

1. The contractors who do the reclamation work should be represented in workshops devoted to assessing the success of reclamation efforts.

2. There is a need for assessing the relative importance of problems noted in the assessment of reclamation work. Is there a minimum size or severity of problem areas that should be considered? Some perspective is needed.

3. Perhaps reclamation assessment studies should make a greater use of statistics in comparing reclaimed areas with undisturbed areas.

4. A post-construction monitoring program must be selective, focusing only on significant problems and not wasting time on irrelevant details.

5. Once the soil and vegetation parameters that are to be studied have been agreed upon, who should do the work and who should pay for it, or how should costs be shared?

11. FACILITATOR'S SUMMARY

(Presented by Mr. Bob Mahnic, Communiplan Inc., Edmonton)

We'll proceed to the final portion of our workshop and begin with the facilitator's summary. It is always a wonderful task to do this, especially at the end of a workshop that's had as much activity and feedback as this one has. The presentations, break-out sessions, and plenary meetings have accumulated almost 40 hours of oral discussions, communication, and information exchange. There have been many good suggestions made and, as has been mentioned, feedback has been very vocal.

I will now provide an overview of the activities of the past two days. The introductory comments and workshop objectives were given to us by John King of Alberta Environment. Then we had three government/industry presentations: Larry Brocke of Alberta Environment and David Lloyd of Alberta Forestry, Lands and Wildlife, presenting the government perspective; and Ian Scott of the CPA provided the industry perspective.

The morning session concluded with two technical presentations by consultants. The first, by Len Knapik of Pedocan Land Evaluation. I'm not a soils expert, but what I did get out of Len Knapik's presentation on soil parameters and assessment of reclamation success was that industry's and government's perspectives as to field measurement techniques and evaluation can vary--widely.

The second technical presentation was made by Dr. David Walker, on vegetation parameters, with assistance from Dr. Annabel Ness Evans of Concordia College on statistical sampling techniques.

What we intended to do in the first series of break-out sessions was to describe as many soil parameters as we could, using basically three measures--What should we measure? Why is it important? Where would it be applicable? We also tried to quantify the rankings using our flash-card system--the new math.

We did arrive at some interesting conclusions at the end of Day 1. Landscape parameters had somehow infiltrated the soils discussion and this caused some heated discussion. These kinds of things can happen in workshops. What it did identify is that there may be some overlap in parameter identification as the presentations by Len Knapik and Dr. David Walker also indicated.

One of the main objectives of this pipeline reclamation workshop was that we examine the utility of vegetation parameters. The soil parameters--the understanding, the measurement--is much more developed and perhaps better understood and applied in the field than are the vegetation parameters. We forcibly created a structure that would cause a group to spend equal time with both parameters. I think that has been very useful.

How did things compare over the first parameter ranking exercise and the second? For soils, topsoil depth was the number one ranked parameter in the first survey. It was number two in survey two. Compaction was number two in the first survey and compaction combined with structure was number three in the second survey. Organic matter was number three in the first survey. Organic matter combined with topsoil subsoil mixing was number one in the second. Number four in the first survey was erosion and soil stability and was again number four in the second survey. In the first survey texture was number five. In the second survey texture ranked the same. In the first survey surface recontouring and surface drainage was number six and, as a landscape parameter, was eliminated before the second survey. In the first survey topsoil/subsoil mixing, as I mentioned, combined in the second with organic matter and was ranked number one. Salinity was eighth in the first survey and ranked sixth in the second. Structure was combined with compaction and rated number three in the second, number nine in the first. Stoniness was ranked number ten in the first survey and number eight in the second. The results correlate very well, so I don't think that we've lost a lot of validity in either of those exercises.

With regard to vegetation, in the first survey ground cover was number one, in the second survey it was ranked third. Plant density in the first survey was number two. Plant density was then combined inadvertently with yield and productivity and became number one in the second survey. Yield and productivity scored very high by itself in the first survey--it was number four. Diversity of species was number three in the first list and in combination

with sustainability, suitability, palatability, aesthetic match, and persistence became number two. Diversity was ranked very high on both surveys. Sustainability, suitability and others in combination became the number two parameter. Rooting pattern and characteristics of rooting were ranked number seven in the first and number six in the second. Again, I don't think the validity of either exercise was damaged by those results. In fact, I think there's strength in the second survey confirming some of the things that happened in the first.

I thought the discussions were very complete. Thanks to the group leader/recorders and discussants in those groups. On to the plenary sessions this afternoon. Again I certainly appreciate the efforts of the participants in completing the group presentations.

So what have we done? I think there are some interesting directions suggested by the discussion. The issue of standards and criteria has come up over and over again and perhaps the discussion over the last 2 days has laid enough of a baseline to move the discussion into criteria and standards.

I would like to conclude by again referring to a statement made in the introductory comments yesterday:

> "*If the ability to use information is power, then information shared is power multiplied.*"

As another step in planning and discussing pipeline reclamation success, this workshop has helped us to exchange and share information, ideas, and experiences. By keeping the channels of communication open and recognizing the myriad of communication-related issues that need to be resolved along with the technical issues, I am confident that these parameters will be fully discussed and, hopefully, standards and criteria established and implemented in the near future.

12. WORKSHOP CLOSING REMARKS

12.1 GOVERNMENT PERSPECTIVE: FUTURE DIRECTION

(Presented by Mr. Larry Brocke, Alberta Environment, Edmonton)

Good afternoon. I too want to congratulate everybody for their efforts over the last two days on behalf of Alberta Environment, and, if I may, on behalf of Alberta Forestry, Lands and Wildlife. We are very appreciative of this process.

Yesterday there were some references made to the APESC group that meets to discuss environmental matters relating to pipelines. Government and industry share this initiative that sets up a series of workshops to deal with specific issues that have been identified. I made some reference yesterday morning as well to some other things that are going on, such as the development of the capability evaluation system, and, lest we forget, the development of our new act and regulations. As most of you may know or have heard by now, Alberta's new Environmental Protection and Enhancement Act was tabled yesterday in the legislature by our Minister, Mr. Klein. It will be debated and it will, I'm sure, be passed.

Our next task is to finish developing the regulations that go with the new Act. The point I want to make is that all these things that I have mentioned--the act and regulations, developing capability systems and this series of workshops are all being driven by the legislation. Maybe a good way to put it is that the new act and the regulations will set up the rules. The capability system when it is developed and tested, will provide the means of measuring reclamation success.

The recommendations from this workshop will be taken forward. Government will make a policy decision. We need to continue with these efforts. I also think we have to recognize some of the deficiencies of the group that we have and that's not a knock on the group at all. It's just that perhaps it should be expanded. One of the groups that isn't represented here is the pipeline contractor. Another group not represented is the public/landowner. There will be more public involvement in all things that we do. Therefore, I think that we need to very seriously consider expanding the group.

Some of you are aware and have been involved in one of the other parallel issues and that is the review of the regulations. We are committed to another round of consultations to complete the discussion on procedural regulations and deal with some of the issues outlined in the regulations or proposals put forward such as--should we be regulating all pipelines? There were others there as well--heavy oil, quarrying, and so forth.

My proposal to you today--to John King and Klaus Exner and others on the Alberta Pipeline Environmental Steering Committee--is that we expand the committee's membership to include the relevant stakeholders that will then be able to discuss the regulations and get people here more involved.

We will continue to increase and improve our communication. I think Bob Mahnic made it very clear in his statement at the beginning of the workshop and again in his summary remarks that communication is very important. That's what we're here for and that's how we're going to continue on. I would also like to suggest that industry, at the corporate level, has to become or will become more responsible and committed to its duties in environmental protection because of the new legislation driving us all.

There will be greater enforcement with the new Act. Some corporate folks are going to get a little nervous and I think its going to help us. It's going to help you on the environmental staff get your jobs done. I think that's good. The government staff role in this whole thing should be providing or facilitating the joint development of the rules that we're going to work under and how we're going to do it. That's what our role should be. We need to open up this process and include the other avenues of activity that are going on in the province as well as pipelines.

12.2 INDUSTRY PERSPECTIVE: FUTURE DIRECTION

(Presented by Mr. Klaus Exner, NOVA Corporation of Alberta, Calgary)

We have two choices--we can go it alone using itsy-bitsy steps or we can cooperate and reach a concensus. I think concensus and cooperation was what this process was all about over the past two days. At the Alberta Pipeline Environmental Steering Committee, we had some discussion about whether or not we were ready for this kind of session. Not all of the people on our committee felt we were ready for a workshop of this nature because the new legislation and regulations were not yet finalized and a variety of other reasons. But in the end I think there was concensus at that level that we need some criteria, we need some common understanding of what the environmental objectives are, we need some consistent application of answering the question--has reclamation been successful or not?

I think we recognize the need for cooperation and concensus. How do we achieve concensus? Well, we can achieve concensus by building on common points. The flip side of that coin is that we exacerbate friction by dwelling on our differences. The challenge that I was going to issue yesterday morning was that we get rid of our extreme views in these workshop sessions. Extreme views are those held by some in industry that say "it's got to be cheap or we can't do it"..."industry is hurting financially and therefore don't lay all this heavy reclamation stuff on us which costs a whole lot of money". An extreme view from the regulatory side might be "that there can be no change from the natural or the baseline"..."no change whatsoever can be tolerated". I think that these are extreme views. My challenge was going to be to cast off our particular employment allegiances, reach back into our professional backgrounds and our areas of training and focus our energies on some common points with respect to environmental protection and what's really required. I think that's just as valid going out of this workshop as coming in because clearly we're not done.

We are going to have to cooperate somewhere down the road from here so that we come up with something that's realistic for environmental protection. We've got two choices folks--if we choose to do it together, I think we get a lot further.

First of all, some people were commenting that there is a lot of discussion at forums like this but very few answers. Some frustration was expressed that this was a pretty diverse group--a tough workshop. So let me say first of all before you dwell on the negative--sure it was a tough workshop, but let's look at the positive side and say thank goodness for the diversity. These questions affect a lot of different people. You mentioned stakeholders--contractors, the public--never mind the kinds of interests that are represented here and the different backgrounds that are represented here. I was impressed by a couple of things. The number of industry and government people. The highest quality consultants in this province are here and all of us in industry thank them for their participation and their patience with us. Thank goodness that we also had a couple of professorial types participating with us because they can sometimes bring us back to reality.

I think there is a positive side to diversity. Participation is a process and yes, maybe there are a few answers and maybe the discussion does get circular. I think in the end it is useful if nothing else to advance our appreciation of some of the other points of view. I heard some comments from people that there was a little bit of entrenchment into some of the traditional views. I also heard some comments that there was very good broad range of professional discussions. One other comment I heard was that these assessments would be made by trained personnel. Pretty big assumption folks, given the range of assessment methodologies that were discussed here over the last couple of days. Let's not forget the training needs for industry and government for all of us involved in this business.

No one workshop is perfect. They're all different, they have different challenges. Some people come away feeling like they've really made some contribution and some people have experienced a measure of frustration.

Ask yourself whether you would fill up that ranking form differently now than when you first started. I understand there were some concerns, at least yesterday. I experienced the same thing this morning. I was handed the sheet of paper. I filled it out hastily because I was told there might be a possibility of getting my votes into the system. After all of the discussion today, I probably would adjust some of my rankings of the parameters because I learned some things from my colleagues and if nothing else this kind of a process can help us all in a kind of way and through that help us reach concensus.

Where do we go with this now, what do we do with these results? There are some linkages to other things going on and Larry Brocke reminded us of the reality that at some point in time Alberta Environment in particular with its legislative authorities, is going to have to draw the line and write some rules of the game for pipeline reclamation. I think we (APESC) need to do some further work as soon as possible on the highest priority items. We should probably work on those areas where we have some measurement tools available and inherent in that should be some consideration also of costs. We need to talk about the practical applications. We also had a lot of discussion from a number of different people here this afternoon about inspection, about focussing on problem areas rather than inspecting by rule, and perhaps getting into a training system. I think we need to keep some perspective on this whole subset of topics in the context of overall environmental protection and the efforts of industry and government.

Larry Brocke also talked about responsibility of the corporate community. We'd rather turn it around and say that we'd like the responsibility to rest where it should and that is with industry. Industry fully recognizes the fact that public participation is the way of the future. Let's move forward and build on the common points rather than dwelling on our differences.

The final comment would be with respect to taking the results of this workshop or subsequent workshops. I would make a plea to Alberta Environment to take into consideration the concensus such as defined with the help of our good facilitators and documentation from this process--take that existing concensus, whatever it may be, into account in "writing the rules of the game". I think one of the key points is that soil parameters aren't the only thing to be used to measure reclamation success. We discussed two different approaches--Tier 1, Tier 2, or stage approaches--starting with an ocular assessment and then more detailed analyses in the way of further plant and soil investigations. I think we have a good base to work on for the future.

APPENDIX 'A'

LIST OF WORKSHOP PARTICIPANTS

Name	Affiliation	Location
Barry Adams	Forestry, Lands & Wildlife, Public Lands	Lethbridge
George Benoit	Forestry, Lands & Wildlife, Forest Service	Calgary
Dan Blackmore	Forestry, Lands & Wildlife, Public Lands	Peace River
Diana Brierley	Forestry, Lands & Wildlife, Public Lands	Edmonton
Larry Brocke	Alberta Environment	Edmonton
Adolf Bruneski	Forestry, Lands & Wildlife, Forest Service	Edmonton
Bill Butterwick	Roan Resources Ltd.	Calgary
Lowell Calder	Forestry, Lands & Wildlife, Public Lands	Lethbridge
Barry Cole	Forestry, Lands & Wildlife, Public Lands	Red Deer
Dennis Cox	Forestry, Lands & Wildlife, Forest Service	Edson
Gary Crouch	Roan Resources Ltd.	Calgary
Murray Doherty	Forestry, Lands & Wildlife, Forest Service	Rocky Mtn. House
Donna Dowell	North Canadian Oils Ltd.	Calgary
Reinhart Dunse	Alberta Government Telephones	Edmonton
Klaus Exner	NOVA Corporation of Alberta	Calgary
Jim Fairgrieve	Forestry, Lands & Wildlife, Public Lands	Fairview
Al Fedkenheuer	NOVA Corporation of Alberta	Calgary
Travis Ferguson	Alberta Environment	Edmonton
Nancy Finlayson	Land Resources Network	Edmonton
Bill Fisher	Alberta Environment	Red Deer
Terry Forkheim	Norcen Energy Resources Ltd.	Calgary
Heather Gerling	Forestry, Lands & Wildlife, Public Lands	Edmonton
Perry Gerwing	Gulf Canada Resources Ltd.	Calgary
Karl Gilmore	TERA Environmental Consultants Ltd.	Calgary
Jeff Hartley	Forestry, Lands & Wildlife, Public Lands	Grande Prairie
Brian Hayward	Opinac Exploration Ltd.	Calgary
John Hermans	Alberta Agriculture	Edmonton
Arnold Janz	Alberta Environment	Edmonton
Duane Johnson	HBT Agra Ltd.	Calgary
John King	Alberta Environment	Edmonton
Len Knapik	Pedocan Land Evaluation Ltd.	Edmonton
Doug Knight	Forestry, Lands & Wildlife, Public Lands	Calgary
Fred Kuipers	Pembina Corporation	Calgary
Sandra Landsburg	NOVA Corporation of Alberta	Calgary
Albert Lees	NOVA Corporation of Alberta	Calgary
Len Leskiw	Can Ag Enterprises Ltd.	Edmonton
David Lloyd	Forestry, Lands & Wildlife, Public Lands	Edmonton
Kirby Lowen	Prairie Seeds Ltd.	Edmonton
Stuart Lunn	PanCanadian Petroleum Ltd.	Calgary
Keith Lyseng	Forestry, Lands and Wildlife, Public Lands	Edmonton
Terry Macyk	Alberta Research Council	Edmonton
Bob Mahnic	Communiplan Inc.	Edmonton
Al Malcolm	Alberta Environment	Peace River
Blair McNeely	Alberta Environment	Medicine Hat

LIST OF WORKSHOP PARTICIPANTS (continued)

Name	Affiliation	Location
Doug Mead	Shell Canada Limited	Calgary
Mike Melnyk	Alberta Environment	Calgary
Kirk Morrison	David Bromley Engineering Ltd.	Calgary
Gary Mott	Abandonment Reclamation Technologies Ltd.	Calgary
Bruce Nesbitt	AEC Oil and Gas Co.	Calgary
Bob Onciul	Alberta Environment	Edmonton
Lionel Peel	Alberta Government Telephones	Edmonton
Chris Powter	Alberta Environment	Edmonton
Craig Richardson	Forestry, Lands & Wildlife, Public Lands	Athabasca
Ian Scott	Canadian Petroleum Association	Calgary
Kelly Scott	Western Oilfields Environmental Services Ltd.	Calgary
Gene Skappak	Renaissance Energy Ltd.	Calgary
Howard Slavinski	Alberta Environment	Edmonton
Judith Smith	Concord Environmental	Calgary
Glen Stalker	Canadian Western Natural Gas Ltd.	Calgary
Rob Staniland	BP Canada Inc.	Calgary
Keith Stretch	Forestry, Lands & Wildlife, Public Lands	Rocky Mtn. House
Clare Tannas	Eastern Slopes Rangeland Consultants	Pincher Creek
Wayne Tedder	Forestry, Lands & Wildlife, Public Lands	Edmonton
Don Thompson	Petro-Canada	Calgary
Dr. John Toogood	Professor Emeritus, Soil Science	Edmonton
Dr. David Walker	David Walker & Associates	Calgary
John Ward	AMOCO Canada Petroleum Company Ltd.	Calgary
Gary Warner	Encor Inc.	Calgary
Mike Willoughby	Forestry, Lands & Wildlife, Forest Service	Edmonton
Bill Wolff	Bissett Resource Consultants Ltd.	Calgary

APPENDIX 'B'

GUIDE TO FIELD ASSESSMENT OF SOIL TEXTURE CLASS

SOIL TEXTURE FIELD TEST

MOIST CAST TEST — Compress some moist soil by clenching it in your hand. If the soil holds together (i.e. forms a cast), then test the strength of the cast by tossing it from hand to hand. The more durable it is, the more clay is present.

RIBBON TEST — Moist soil is rolled into a cigarette shape and then squeezed out between the thumb and forefinger to form the longest and thinnest ribbon possible.

FEEL TESTS

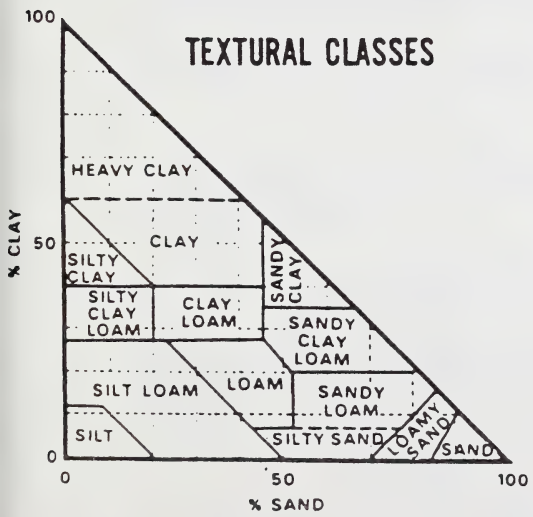
GRAININESS TEST — Soil is rubbed between thumb and fingers to assess the % sand. Sand feels grainy.

DRY FEEL TEST — Soils with >50% sand. Soil is rubbed in the palm of the hand to dry it and to separate and estimate the size of the individual sand particles. The sand particles are then allowed to fall out of the hand and the amount of finer material (silt & clay) remaining is noted.

STICKINESS TEST — Soil is wetted and compressed between the thumb and forefinger. Degree of stickiness is determined by noting how strongly it adheres to the thumb and forefinger upon release of pressure and how much it stretches.

TASTE TEST — A small amount of soil is worked between the front teeth. Sand is distinguished as individual grains which grit sharply against the teeth. Silt particles are identified as a general fine grittiness, but individual grains cannot be identified. Clay particles have no grittiness.

SHINE TEST — A small amount of moderately dry soil is rolled into a ball and rubbed once or twice against a hard, smooth object such as a knife blade or thumb nail. A shine on the ball indicates clay in the soil.



FIELD TEST CHARACTERISTICS OF SOIL TEXTURE CLASSES

TEXTURE CLASS	FEEL TEST	MOIST CAST TEST	RIBBON TEST	TASTE TEST	SHINE TEST
SAND	grainy with little floury material	no cast	none	unnecessary	unnecessary
LOAMY SAND	grainy with slight amount of floury material	very weak cast, no handling	none	unnecessary	unnecessary
SILTY SAND	grainy with moderate amount of floury material	weak cast, no handling	none	unnecessary	unnecessary
SANDY LOAM	grainy with considerable amount of floury material	weak cast, allows careful handling	none	unnecessary	unnecessary
LOAM	fairly soft and smooth with evident graininess	good cast, readily handled	barely begins to ribbon	unnecessary	unnecessary
SILT LOAM	floury with slight graininess	weak cast, allows careful handling	flakes, rather than ribbons	silt grittiness, some sand graininess	unnecessary
SILT	very floury	weak cast, allows careful handling	flakes, rather than ribbons	silt grittiness	unnecessary
SANDY CLAY LOAM	very substantial graininess	moderate cast	short and thick (< 3cm)	sand graininess clearly evident	slightly shiny
CLAY LOAM	moderate graininess	strong cast	fairly thin, breaks readily, barely supports own weight	sand graininess clearly evident	slightly shiny
SILTY CLAY LOAM	smooth and floury	strong cast	fairly thin, breaks readily, barely supports own weight	silt grittiness	slightly shiny
SANDY CLAY	substantial graininess	strong cast	thin, fairly long (5 - 7.5 cm), holds own weight	sand graininess clearly evident	moderately shiny
SILTY CLAY	smooth	very strong cast	thin, fairly long (5 - 7.5cm) holds own weight	silt grittiness	moderately shiny
CLAY	smooth	very strong cast	very thin, long (7.5 cm)	smooth	very shiny

APPENDIX 'C'

STATISTICAL DETAILS FOR VEGETATION SAMPLING

The statistical basis for the recommendations in this report include the assumption that the measurement variable approximates a binomial distribution. Although, the true sampling distribution is more likely to follow a hypergeometric function because sampling is without replacement, this assumption of binomial approximation is a statistically sound one in this case because the number of sample units available in a typical reclamation site is very large relative to the number of sample units being assessed.
If the population is not large then these estimates will be conservative. The formulas used to determine error rate and power are presented below.

To determine the sample proportion for rejection of the null:
Type I error set at $\alpha=0.10$
$Z_{.10}=-1.28$

Ho: P=0.90
P=0.90
Q=0.10
n=80
$\sigma_p=\sqrt{PQ/n} = \sqrt{0.90 \cdot 0.10/80} = .0335$

This means that if 90% of the site square metre units meet the standard, the sample proportion meeting the standard will vary on the average ~3% from 90. Given that expected variability the critical sample proportion that will lead to rejection of the null is:

$p=P+Z\sigma_p = 0.90-1.28\sqrt{0.90 \cdot 0.10/80} = 0.8571$

To determine power for detecting a difference of 10%.

Ha: P=0.80
P=0.80
Q=0.20
$Z=\frac{0.8571-0.80}{\sqrt{0.80 \cdot 0.20/80}} = 1.2761$

Type II error = $\beta=0.1003$
Power = $1-\beta=0.8997$

RECLAMATION RESEARCH REPORTS

1. **RRTAC 79-2: Proceedings: Workshop on Native Shrubs in Reclamation. P.F. Ziemkiewicz, C.A. Dermott and H.P. Sims (Editors). 104 pp. No longer available.**

The Workshop was organized as the first step in developing a Native Shrub reclamation research program. The Workshop provided a forum for the exchange of information and experiences on three topics: propagation; outplanting; and, species selection. Seven papers and the results of three discussion groups are presented.

2. **RRTAC 80-1: Test Plot Establishment: Native Grasses for Reclamation. R.S. Sadasivaiah and J. Weijer. 19 pp. No longer available.**

The report details the species used at three test plots in Alberta's Eastern Slopes (one at Caw Creek Ridge and two at Cadomin). Site preparation, experimental design, and planting method are also described.

3. **RRTAC 80-2: Alberta's Reclamation Research Program - 1979. Reclamation Research Technical Advisory Committee. 22 pp. No longer available.**

This report describes the expenditure of $1,190,006 of Alberta Heritage Savings Trust Fund monies on research under the Land Reclamation Program. The report outlines the objectives and research strategies of the four program areas, and describes the projects funded under each program.

4. **RRTAC 80-3: The Role of Organic Compounds in Salinization of Plains Coal Mining Sites. N.S.C. Cameron et al. 46 pp. $10.00**

This is a literature review of the chemistry of sodic mine spoil and the changes expected to occur in groundwater.

5. **RRTAC 80-4: Proceedings: Workshop on Reconstruction of Forest Soils in Reclamation. P.F. Ziemkiewicz, S.K. Takyi and H.F. Regier (Editors). 160 pp. $10.00**

Experts in the field of forestry and forest soils report on research relevant to forest soil reconstruction and discuss the most effective means of restoring forestry capability of mined lands.

6. **RRTAC 80-5: Manual of Plant Species Suitability for Reclamation in Alberta. L.E. Watson, R.W. Parker and D.F. Polster. 2 vols, 541 pp. No longer available; replaced by RRTAC 89-4.**

Forty-three grass, fourteen forb, and thirty-four shrub and tree species are assessed in terms of their suitability for use in reclamation. Range maps, growth habit, propagation, tolerance, and availability information are provided.

7. **RRTAC 81-1: The Alberta Government's Reclamation Research Program - 1980. Reclamation Research Technical Advisory Committee. 25 pp. No longer available.**

This report describes the expenditure of $1,455,680 of Alberta Heritage Savings Trust Fund monies on research under the Land Reclamation Program. The report outlines the objectives and research strategies of the four program areas, and describes the projects funded under each program.

8. **RRTAC 81-2: 1980 Survey of Reclamation Activities in Alberta. D.G. Walker and R.L. Rothwell. 76 pp. $10.00**

This survey is an update of a report prepared in 1976 on reclamation activities in Alberta, and includes research and operational reclamation, locations, personnel, etc.

9. **RRTAC 81-3: Proceedings: Workshop on Coal Ash and Reclamation. P.F. Ziemkiewicz, R. Stein, R. Leitch and G. Lutwick (Editors). 253 pp. $10.00**

Presents nine technical papers on the chemical, physical, and engineering properties of Alberta fly and bottom ashes, revegetation of ash disposal sites, and use of ash as a soil amendment. Workshop discussions and summaries are also included.

10. **RRTAC 82-1: Land Surface Reclamation: An International Bibliography. H.P. Sims and C.B. Powter. 2 vols, 292 pp. $10.00**

Literature to 1980 pertinent to reclamation in Alberta is listed in Vol. 1 and is also on the University of Alberta computing system (in a SPIRES database called RECLAIM). Vol. 2 comprises the keyword index and computer access manual.

11. **RRTAC 82-2: A Bibliography of Baseline Studies in Alberta: Soils, Geology, Hydrology and Groundwater. C.B. Powter and H.P. Sims. 97 pp. $5.00**

This bibliography provides baseline information for persons involved in reclamation research or in the preparation of environmental impact assessments. Materials, up to date as of December 1981, are available in the Alberta Environment Library.

12. **RRTAC 82-3: The Alberta Government's Reclamation Research Program - 1981. Reclamation Research Technical Advisory Committee. 22 pp. No longer available.**

This report describes the expenditure of $1,499,525 of Alberta Heritage Savings Trust Fund monies on research under the Land Reclamation Program. The report outlines the objectives and research strategies of the four program areas, and describes the projects funded under each program.

13. **RRTAC 83-1: Soil Reconstruction Design for Reclamation of Oil Sand Tailings. Monenco Consultants Ltd. 185 pp. No longer available**

Volumes of peat and clay required to amend oil sand tailings were estimated based on existing literature. Separate soil prescriptions were made for spruce, jack pine, and herbaceous cover types. The estimates form the basis of field trials.

14. **RRTAC 83-2: The Alberta Government's Reclamation Research Program - 1982. Reclamation Research Technical Advisory Committee. 25 pp. No longer available.**

This report describes the expenditure of $1,536,142 of Alberta Heritage Savings Trust Fund monies on research under the Land Reclamation Program. The report outlines the objectives and research strategies of the four program areas, and describes the projects funded under each program.

15. **RRTAC 83-3: Evaluation of Pipeline Reclamation Practices on Agricultural Lands in Alberta. Hardy Associates (1978) Ltd. 205 pp. No longer available.**

Available information on pipeline reclamation practices was reviewed. A field survey was then conducted to determine the effects of pipe size, age, soil type, construction method, etc. on resulting crop production.

16. **RRTAC 83-4: Proceedings: Effects of Coal Mining on Eastern Slopes Hydrology. P.F. Ziemkiewicz (Editor). 123 pp. $10.00**

Technical papers are presented dealing with the impacts of mining on mountain watersheds, their flow characteristics, and resulting water quality. Mitigative measures and priorities were also discussed.

17. **RRTAC 83-5: Woody Plant Establishment and Management for Oil Sands Mine Reclamation. Techman Engineering Ltd. 124 pp. No longer available.**

This is a review and analysis of information on planting stock quality, rearing techniques, site preparation, planting, and procedures necessary to ensure survival of trees and shrubs in oil sand reclamation.

18. **RRTAC 84-1: Land Surface Reclamation: A Review of the International Literature. H.P. Sims, C.B. Powter and J.A. Campbell. 2 vols, 1549 pp. $20.00**

Nearly all topics of interest to reclamationists including mining methods, soil amendments, revegetation, propagation and toxic materials are reviewed in light of the international literature.

19. **RRTAC 84-2: Propagation Study: Use of Trees and Shrubs for Oil Sand Reclamation. Techman Engineering Ltd. 58 pp. $10.00**

This report evaluates and summarizes all available published and unpublished information on large-scale propagation methods for shrubs and trees to be used in oil sand reclamation.

20. **RRTAC 84-3: Reclamation Research Annual Report - 1983. P.F. Ziemkiewicz. 42 pp. $5.00**

This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results, and expenditures.

21. **RRTAC 84-4: Soil Microbiology in Land Reclamation. D. Parkinson, R.M. Danielson, C. Griffiths, S. Visser and J.C. Zak. 2 vols, 676 pp. $10.00**

This is a collection of five reports dealing with re-establishment of fungal decomposers and mycorrhizal symbionts in various amended spoil types.

22. **RRTAC 85-1: Proceedings: Revegetation Methods for Alberta's Mountains and Foothills. P.F. Ziemkiewicz (Editor). 416 pp. No longer available.**

Results of long-term experiments and field experience on species selection, fertilization, reforestation, topsoiling, shrub propagation and establishment are presented.

23. **RRTAC 85-2: Reclamation Research Annual Report - 1984. P.F. Ziemkiewicz. 29 pp. $5.00**

This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results, and expenditures.

24. **RRTAC 86-1: A Critical Analysis of Settling Pond Design and Alternative Technologies. A. Somani. 372 pp. $10.00**

The report examines the critical issue of settling pond design, and sizing and alternative technologies. The study was co-funded with The Coal Association of Canada.

25. **RRTAC 86-2: Characterization and Variability of Soil Reconstructed after Surface Mining in Central Alberta. T.M. Macyk. 146 pp. No longer available.**

Reconstructed soils representing different materials handling and replacement techniques were characterized, and variability in chemical and physical properties was assessed. The data obtained indicate that reconstructed soil properties are determined largely by parent material characteristics and further tempered by materials handling procedures. Mining tends to create a relatively homogeneous soil landscape in contrast to the mixture of diverse soils found before mining.

26. **RRTAC 86-3: Generalized Procedures for Assessing Post-Mining Groundwater Supply Potential in the Plains of Alberta - Plains Hydrology and Reclamation Project. M.R. Trudell and S.R. Moran. 30 pp. $5.00**

In the Plains region of Alberta, the surface mining of coal generally occurs in rural, agricultural areas in which domestic water supply requirements are met almost entirely by groundwater. Consequently, an important aspect of the capability of reclaimed lands to satisfy the needs of a residential component is the post-mining availability of groundwater. This report proposes a sequence of steps or procedures to identify and characterize potential post-mining aquifers.

27. **RRTAC 86-4: Geology of the Battle River Site: Plains Hydrology and Reclamation Project. A. Maslowski-Schutze, R. Li, M. Fenton and S.R. Moran. 86 pp. $10.00**

This report summarizes the geological setting of the Battle River study site. It is designed to provide a general understanding of geological conditions adequate to establish a framework for hydrogeological and general reclamation studies. The report is not intended to be a detailed synthesis such as would be required for mine planning purposes.

28. **RRTAC 86-5: Chemical and Mineralogical Properties of Overburden: Plains Hydrology and Reclamation Project. A. Maslowski-Schutze. 71 pp. $10.00**

This report describes the physical and mineralogical properties of overburden materials in an effort to identify individual beds within the bedrock overburden that might be significantly different in terms of reclamation potential.

29. **RRTAC 86-6: Post-Mining Groundwater Supply at the Battle River Site: Plains Hydrology and Reclamation Project. M.R. Trudell, G.J. Sterenberg and S.R. Moran. 49 pp. $5.00**

The report deals with the availability of water supply in or beneath cast overburden to support post-mining land use, including both quantity and quality considerations. The study area is in the Battle River Mining area in east-central Alberta.

30. **RRTAC 86-7: Post-Mining Groundwater Supply at the Highvale Site: Plains Hydrology and Reclamation Project. M.R. Trudell. 25 pp. $5.00**

This report evaluates the availability of water supply in or beneath cast overburden to support post-mining land use, including both quantity and quality considerations. The study area is the Highvale mining area in west-central Alberta.

31. **RRTAC 86-8: Reclamation Research Annual Report - 1985. P.F. Ziemkiewicz. 54 pp. $5.00**

This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results, and expenditures.

32. **RRTAC 86-9: Wildlife Habitat Requirements and Reclamation Techniques for the Mountains and Foothills of Alberta. J.E. Green, R.E. Salter and D.G. Walker. 285 pp. No longer available.**

This report presents a review of relevant North American literature on wildlife habitats in mountain and foothills biomes, reclamation techniques, potential problems in wildlife habitat reclamation, and potential habitat assessment methodologies. Four biomes (Alpine, Subalpine, Montane, and Boreal Uplands) and 10 key wildlife species (snowshoe hare, beaver, muskrat, elk, moose, caribou, mountain goat, bighorn sheep, spruce grouse, and white-tailed ptarmigan) are discussed. The study was co-funded with The Coal Association of Canada.

33. **RRTAC 87-1: Disposal of Drilling Wastes. L.A. Leskiw, E. Reinl-Dwyer, T.L. Dabrowski, B.J. Rutherford and H. Hamilton. 210 pp. No longer available.**

Current drilling waste disposal practices are reviewed and criteria in Alberta guidelines are assessed. The report also identifies research needs and indicates mitigation measures. A manual provides a decision-making flowchart to assist in selecting methods of environmentally safe waste disposal.

34. **RRTAC 87-2: Minesoil and Landscape Reclamation of the Coal Mines in Alberta's Mountains and Foothills. A.W. Fedkenheuer, L.J. Knapik and D.G. Walker. 174 pp. No longer available.**

This report reviews current reclamation practices with regard to site and soil reconstruction and re-establishment of biological productivity. It also identifies research needs in the Mountain-Foothills area. The study was co-funded with The Coal Association of Canada.

35. **RRTAC 87-3: Gel and Saline Drilling Wastes in Alberta: Workshop Proceedings. D.A. Lloyd (Compiler). 218 pp. No longer available.**

Technical papers were presented which describe: mud systems used and their purpose; industrial constraints; government regulations, procedures and concerns; environmental considerations in waste disposal; and toxic constituents of drilling wastes. Answers to a questionnaire distributed to participants are included in an appendix.

36. **RRTAC 87-4: Reclamation Research Annual Report - 1986. 50 pp. No longer available.**

This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results, and expenditures.

37. **RRTAC 87-5: Review of the Scientific Basis of Water Quality Criteria for the East Slope Foothills of Alberta. Beak Associates Consulting Ltd. 46 pp. $10.00**

The report reviews existing Alberta guidelines to assess the quality of water drained from coal mine sites in the East Slope Foothills of Alberta. World literature was reviewed within the context of the East Slopes environment and current mining operations. The ability of coal mine operators to meet the various guidelines is discussed. The study was co-funded with The Coal Association of Canada.

38. **RRTAC 87-6: Assessing Design Flows and Sediment Discharge on the Eastern Slopes. Hydrocon Engineering (Continental) Ltd. and Monenco Consultants Ltd. 97 pp. $10.00**

The report provides an evaluation of current methodologies used to determine sediment yields due to rainfall events in well-defined areas. Models are available in Alberta to evaluate water and sediment discharge in a post-mining situation. SEDIMOT II (Sedimentology Disturbed Modelling Techniques) is a single storm model that was developed specifically for the design of sediment control structures in watersheds disturbed by surface mining and is well suited to Alberta conditions. The study was co-funded with The Coal Association of Canada.

39. **RRTAC 87-7: The Use of Bottom Ash as an Amendment to Sodic Spoil. S. Fullerton. 83 pp. No longer available.**

The report details the use of bottom ash as an amendment to sodic coal mine spoil. Several rates and methods of application of bottom ash to sodic spoil were tested to determine which was the best at reducing the effects of excess sodium and promoting crop growth. Field trials were set up near the Vesta mine in East Central Alberta using ash readily available from a nearby coal-fired thermal generating station. The research indicated that bottom ash incorporated to a depth of 30 cm using a subsoiler provided the best results.

40. **RRTAC 87-8: Waste Dump Design for Erosion Control. R.G. Chopiuk and S.E. Thornton. 45 pp. $5.00**

This report describes a study to evaluate the potential influence of erosion from reclaimed waste dumps on downslope environments such as streams and rivers. Sites were selected from coal mines in Alberta's mountains and foothills, and included resloped dumps of different configurations and ages, and having different vegetation covers. The study concluded that the average annual amount of surface erosion is minimal. As expected, erosion was greatest on slopes which were newly regraded. Slopes with dense grass cover showed no signs of erosion. Generally, the amount of erosion decreased with time, as a result of initial loss of fine particles, the formation of a weathered surface, and increased vegetative cover.

41. **RRTAC 87-9: Hydrogeology and Groundwater Chemistry of the Battle River Mining Area. M.R. Trudell, R.L. Faught and S.R. Moran. 97 pp. No longer available.**

This report describes the premining geologic conditions in the Battle River coal mining area including the geology as well as the groundwater flow patterns, and the groundwater quality of a sequence of several water-bearing formations extending from the surface to a depth of about 100 metres.

42. **RRTAC 87-10: Soil Survey of the Plains Hydrology and Reclamation Project - Battle River Project Area. T.M. Macyk and A.H. MacLean. 62 pp. plus 8 maps. $10.00**

The report evaluates the capability of post-mining landscapes and assesses the changes in capability as a result of mining, in the Battle River mining area. Detailed soils information is provided in the report for lands adjacent to areas already mined as well as for lands that are destined to be mined. Characterization of the reconstructed soils in the reclaimed areas is also provided. Data were collected from 1979 to 1985. Eight maps supplement the report.

43. **RRTAC 87-11: Geology of the Highvale Study Site: Plains Hydrology and Reclamation Project. A. Maslowski-Schutze. 78 pp. $10.00**

The report is one of a series that describes the geology, soils and groundwater conditions at the Highvale Coal Mine study site. The purpose of the study was to establish a summary of site geology to a level of detail necessary to provide a framework for studies of hydrogeology and reclamation.

44. **RRTAC 87-12: Premining Groundwater Conditions at the Highvale Site. M.R. Trudell and R. Faught. 83 pp. $10.00**

This report presents a detailed discussion of the premining flow patterns, hydraulic properties, and isotopic and hydrochemical characteristics of five layers within the Paskapoo Geological Formation, the underlying sandstone beds of the Upper Horseshoe Canyon Formation, and the surficial glacial drift.

45. **RRTAC 87-13: An Agricultural Capability Rating System for Reconstructed Soils. T.M. Macyk. 27 pp. $5.00**

This report provides the rationale and a system for assessing the agricultural capability of reconstructed soils. Data on the properties of the soils used in this report are provided in RRTAC 86-2.

46. **RRTAC 88-1: A Proposed Evaluation System for Wildlife Habitat Reclamation in the Mountains and Foothills Biomes of Alberta: Proposed Methodology and Assessment Handbook. T.R. Eccles, R.E. Salter and J.E. Green. 101 pp. plus appendix. $10.00**

The report focuses on the development of guidelines and procedures for the assessment of reclaimed wildlife habitat in the Mountains and Foothills regions of Alberta. The technical section provides background documentation including a discussion of reclamation planning, a listing of reclamation habitats and associated key wildlife species, conditions required for development, recommended revegetation species, suitable reclamation techniques, a description of the recommended assessment techniques and a glossary of basic terminology. The assessment handbook section contains basic information necessary for evaluating wildlife habitat reclamation, including assessment scoresheets for 15 different reclamation habitats, standard methodologies for measuring habitat variables used as assessment criteria, and minimum requirements for certification. This handbook is intended as a field manual that could potentially be used by site operators and reclamation officers. The study was co-funded with The Coal Association of Canada.

47. **RRTAC 88-2: Plains Hydrology and Reclamation Project: Spoil Groundwater Chemistry and its Impacts on Surface Water. M.R. Trudell (Compiler). 135 pp. $10.00**

Two reports comprise this volume. The first "Chemistry of Groundwater in Mine Spoil, Central Alberta," describes the chemical make-up of spoil groundwater at four mines in the Plains of Alberta. It explains the nature and magnitude of changes in groundwater chemistry following mining and reclamation. The second report, "Impacts of Surface Mining on Chemical Quality of Streams in the Battle River Mining Area," describes the chemical quality of water in streams in the Battle River mining area, and the potential impact of groundwater discharge from surface mines on these streams.

48. **RRTAC 88-3: Revegetation of Oil Sands Tailings: Growth Improvement of Silver-berry and Buffalo-berry by Inoculation with Mycorrhizal Fungi and N_2-Fixing Bacteria. S. Visser and R.M. Danielson. 98 pp. $10.00**

The report provides results of a study: (1) To determine the mycorrhizal affinities of various actinorrhizal shrubs in the Fort McMurray, Alberta region; (2) To establish a basis for justifying symbiont inoculation of buffalo-berry and silver-berry; (3) To develop a growing regime for the greenhouse production of mycorrhizal, nodulated silver-berry and buffalo-berry; and, (4) To conduct a field trial on reconstructed soil on the Syncrude Canada Limited oil sands site to critically evaluate the growth performance of inoculated silver-berry and buffalo-berry as compared with their un-inoculated counterparts.

49. **RRTAC 88-4: Plains Hydrology and Reclamation Project: Investigation of the Settlement Behaviour of Mine Backfill. D.R. Pauls (compiler). 135 pp. $10.00**

This three part volume covers the laboratory assessment of the potential for subsidence in reclaimed landscapes. The first report in this volume, "Simulation of Mine Spoil Subsidence by Consolidation Tests," covers laboratory simulations of the subsidence process particularly as it is influenced by resaturation of mine spoil. The second report, "Water Sensitivity of Smectitic Overburden: Plains Region of Alberta," describes a series of laboratory tests to determine the behaviour of overburden materials when brought into contact with water. The report entitled "Classification System for Transitional Materials: Plains Region of Alberta," describes a lithological classification system developed to address the characteristics of the smectite rich, clayey transition materials that make up the overburden in the Plains of Alberta.

50. **RRTAC 88-5: Ectomycorrhizae of Jack Pine and Green Alder: Assessment of the Need for Inoculation, Development of Inoculation Techniques and Outplanting Trials on Oil Sand Tailings. R.M. Danielson and S. Visser. 177 pp. $10.00**

The overall objective of this research was to characterize the mycorrhizal status of Jack Pine and Green Alder which are prime candidates as reclamation species for oil sand tailings and to determine the potential benefits of mycorrhizae on plant performance. This entailed determining the symbiont status of container-grown nursery stock and the quantity and quality of inoculum in reconstructed soils, developing inoculation techniques and finally, performance testing in an actual reclamation setting.

51. **RRTAC 88-6: Reclamation Research Annual Report - 1987. Reclamation Research Technical Advisory Committee. 67 pp. No longer available.**

This annual report describes the expenditure of $500,000.00 of Alberta Heritage Savings Trust Fund monies on research under the Land Reclamation Program. The report outlines the objectives and research strategies of the four program areas, and describes the projects funded under each program.

52. **RRTAC 88-7: Baseline Growth Performance Levels and Assessment Procedure for Commercial Tree Species in Alberta's Mountains and Foothills. W.R. Dempster and Associates Ltd. 66 pp. $5.00**

Data on juvenile height development of lodgepole pine and white spruce from cut-over or burned sites in the Eastern Slopes of Alberta were used to define reasonable expectations of early growth performance as a basis for evaluating the success of reforestation following coal mining. Equations were developed predicting total seedling height and current annual height increment as a function of age and elevation. Procedures are described for applying the equations, with further adjustments for drainage class and aspect, to develop local growth performance against these expectations. The study was co-funded with The Coal Association of Canada.

53. **RRTAC 88-8: Alberta Forest Service Watershed Management Field and Laboratory Methods. A.M.K. Nip and R.A. Hursey. 4 Sections, various pagings. $10.00**

Disturbances such as coal mines in the Eastern Slopes of Alberta have the potential for affecting watershed quality during and following mining. The collection of hydrometric, water quality and hydrometeorologic information is a complex task. A variety of instruments and measurement methods are required to produce a record of hydrologic inputs and outputs for a watershed basin. There is a growing awareness and recognition that standardization of data acquisition methods is required to ensure data comparability, and to allow comparison of data analyses. The purpose of this manual is to assist those involved in the field of data acquisition by outlining methods, practices and instruments which are reliable and recognized by the International Organization for Standardization.

54. **RRTAC 88-9: Computer Analysis of the Factors Influencing Groundwater Flow and Mass Transport in a System Disturbed by Strip Mining. F.W. Schwartz and A.S. Crowe. 78 pp. $10.00**

Work presented in this report demonstrates how a groundwater flow model can be used to study a variety of mining-related problems such as declining water levels in areas around the mine as a result of dewatering, and the development of high water tables in spoil once resaturation is complete. This report investigates the role of various hydrogeological parameters that influence the magnitude, timing, and extent of water level changes during and following mining at the regional scale. The modelling approach described here represents a major advance on existing work.

55. **RRTAC 88-10: Review of Literature Related to Clay Liners for Sump Disposal of Drilling Wastes. D.R. Pauls, S.R. Moran and T. Macyk. 61 pp. No longer available.**

The report reviews and analyses the effectiveness of geological containment of drilling waste in sumps. Of particular importance was the determination of changes in properties of clay materials as a result of contact with highly saline brines containing various organic chemicals.

56. **RRTAC 88-11: Highvale Soil Reconstruction Project: Five Year Summary. D.N. Graveland, T.A. Oddie, A.E. Osborne and L.A. Panek. 104 pp. $10.00**

This report provides details of a five year study to determine a suitable thickness of subsoil to replace over minespoil in the Highvale plains coal mine area to ensure return of agricultural capability. The study also examined the effect of slope and aspect on agricultural capability. This study was funded and managed with industry assistance.

57. **RRTAC 88-12: A Review of the International Literature on Mine Spoil Subsidence. J.D. Scott, G. Zinter, D.R. Pauls and M.B. Dusseault. 36 pp. $10.00**

The report reviews available engineering literature relative to subsidence of reclaimed mine spoil. The report covers methods for site investigation, field monitoring programs and lab programs, mechanisms of settlement, and remedial measures.

58. **RRTAC 89-1: Reclamation Research Annual Report - 1988. 74 pp. $5.00**

This annual report describes the expenditure of $280,000.00 of Alberta Heritage Savings Trust Fund monies on research under the Land Reclamation Program. The report outlines the objectives and research strategies of the four program areas, and describes the projects funded under each program.

59. **RRTAC 89-2: Proceedings of the Conference: Reclamation, A Global Perspective. D.G. Walker, C.B. Powter and M.W. Pole (Compilers). 2 Vols., 854 pp. No longer available.**

Over 250 delegates from all over the world attended this conference held in Calgary in August, 1989. The proceedings contains over 85 peer-reviewed papers under the following headings: A Global Perspective; Northern and High Altitude Reclamation; Fish & Wildlife and Rangeland Reclamation; Water; Herbaceous Revegetation; Woody Plant Revegetation and Succession; Industrial and Urban Sites; Problems and Solutions; Sodic and Saline Materials; Soils and Overburden; Acid Generating Materials; and, Mine Tailings.

60. **RRTAC 89-3: Efficiency of Activated Charcoal for Inactivation of Bromacil and Tebuthiuron Residues in Soil. M.P. Sharma. 38 pp. ISBN 0-7732-0878-X. $5.00**

Bromacil and Tebuthiuron were commonly used soil sterilants on well sites, battery sites and other industrial sites in Alberta where total vegetation control was desired. Activated charcoal was found to be effective in binding the sterilants in greenhouse trials. The influence of factors such as herbicide:charcoal concentration ratio, soil texture, organic matter content, soil moisture, and the time interval between charcoal incorporation and plant establishment were evaluated in the greenhouse.

61. **RRTAC 89-4: Manual of Plant Species Suitability for Reclamation in Alberta - 2nd Edition. Hardy BBT Limited. 436 pp. ISBN 0-7732-0882-8. $10.00.**

This is an updated version of RRTAC Report 80-5 which describes the characteristics of 43 grass, 14 forb and 34 shrub and tree species which make them suitable for reclamation in Alberta. The report has been updated in several important ways: a line drawing of each species has been added; the range maps for each species have been redrawn based on an ecosystem classification of the province; new information (to 1990) has been added, particularly in the sections on reclamation use; and the material has been reorganized to facilitate information retrieval. Of greatest interest is the performance chart that precedes each species and the combined performance charts for the grass, forb, and shrub/tree groups. These allow the reader to pick out at a glance species that may suit their particular needs. The report was produced with the assistance of a grant from the Recreation, Parks and Wildlife Foundation.

62. **RRTAC 89-5: Battle River Soil Reconstruction Project Five Year Summary. L.A. Leskiw. 188 pp. $10.00**

This report summarizes the results of a five year study to investigate methods required to return capability to land surface mined for coal in the Battle River area of central Alberta. Studies were conducted on: the amounts of subsoil required, the potential of gypsum and bottom ash to amend adverse soil properties, and the effects of slope angle and aspect. Forage and cereal crop growth was evaluated, as were changes in soil chemistry, density and moisture holding characteristics.

63. **RRTAC 89-6: Detailed Sampling, Characterization and Greenhouse Pot Trials Relative to Drilling Wastes in Alberta. T.M. Macyk, F.I. Nikiforuk, S.A. Abboud and Z.W. Widtman. 228 pp. $10.00**

This report summarizes a three-year study of the chemistry of freshwater gel, KCl, NaCl, DAP, and invert drilling wastes, both solids and liquids, from three regions in Alberta: Cold Lake, Eastern Slopes, and Peace River/Grande Prairie. A greenhouse study also examined the effects of adding various amounts of waste to soil on grass growth and soil chemistry. Methods for sampling drilling wastes are recommended.

64. **RRTAC 89-7: A User's Guide for the Prediction of Post-Mining Groundwater Chemistry from Overburden Characteristics. M.R. Trudell and D.C. Cheel. 55 pp. $5.00**

This report provides the detailed procedure and methodology that is required to produce a prediction of post-mining groundwater chemistry for plains coal mines, based on the soluble salt characteristics of overburden materials. The fundamental component of the prediction procedure is the geochemical model PHREEQE, developed by the U.S. Geological Survey, which is in the public domain and has been adapted for use on personal computers.

65. **RRTAC 90-1: Reclamation Research Annual Report - 1989. 62 pp. No longer available.**

This annual report describes the expenditure of $480,000.00 of Alberta Heritage Savings Trust Fund monies on research under the Land Reclamation Program. The report outlines the objectives and research strategies of the four program areas, and describes the projects funded under each program.

66. **RRTAC 90-2: Initial Selection for Salt Tolerance in Rocky Mountain Accessions of Slender Wheatgrass and Alpine Bluegrass. R. Hermesh, J. Woosaree, B.A. Darroch, S.N. Acharya and A. Smreciu. 40 pp. $5.00**

Selected lines of slender wheatgrass and alpine bluegrass collected from alpine and subalpine regions of Alberta as part of another native grass project were evaluated for their ability to emerge in a saline medium. Eleven slender wheatgrass and 72 alpine bluegrass lines had a higher percentage emergence than the Orbit Tall Wheatgrass control (a commonly available commercial grass). This means that as well as an ability to grow in high elevation areas, these lines may also be suitable for use in areas where saline soil conditions are present. Thus, their usefulness for reclamation has expanded.

67. **RRTAC 90-3: Natural Plant Invasion into Reclaimed Oil Sands Mine Sites. Hardy BBT Limited. 65 pp. $5.00**

Vegetation data from reclaimed sites on the Syncrude and Suncor oil sands mines have been summarized and related to site and factors and reclamation methods. Natural invasion into sites seeded to agronomic grasses and legumes was minimal even after 15 years. Invasion was slightly greater in sites seeded to native species, but was greatest on sites that were not seeded. Invasion was mostly from agronomic species and native forbs; native shrub and tree invasion was minimal.

68. **RRTAC 90-4: Physical and Hydrological Characteristics of Ponds in Reclaimed Upland Landscape Settings and their Impact on Agricultural Capability. S.R. Moran, T.M. Macyk, M.R. Trudell and M.E. Pigot, Alberta Research Council. 76 pp. $5.00**

The report details the results and conclusions from studying a pond in a reclaimed upland site in Vesta Mine. The pond formed as a result of two factors: (1) a berm which channelled meltwater into a series of subsidence depressions, forming a closed basin; and (2) low hydraulic conductivity in the lower subsoil and upper spoil as a result of compaction during placement and grading which did not allow for rapid drainage of ponded water. Ponds such as this in the reclaimed landscape can affect agricultural capability by: (1) reducing the amount of farmable land (however, the area covered by these ponds in this region is less than half of that found in unmined areas); and, (2) creating the conditions necessary for the progressive development of saline and potentially sodic soils in the area adjacent to the pond.

69. **RRTAC 90-5: Review of the Effects of Storage on Topsoil Quality. Thurber Consultants Ltd., Land Resources Network Ltd., and Norwest Soil Research Ltd. 116 pp. $10.00**

The international literature was reviewed to determine the potential effects of storage on topsoil quality. Conclusions from the review indicated that storage does not appear to have any severe and longterm effects on topsoil quality. Chemical changes may be rectified with the use of fertilizers or manure. Physical changes appear to be potentially less serious than changes in soil quality associated with the stripping and respreading operations. Soil biotic populations appear to revert to pre-disturbance levels of activity within acceptable timeframes. Broad, shallow storage piles that are seeded to acceptable grass and legume species are recommended; agrochemical use should be carefully controlled to ensure soil biota are not destroyed.

70. **RRTAC 90-6: Proceedings of the Industry/Government Three-Lift Soils Handling Workshop. Deloitte & Touche. 168 pp. $10.00**

This report documents the results of a two-day workshop on the issue of three-lift soils handling for pipelines. The workshop was organized and funded by RRTAC, the Canadian Petroleum Association and the Independent Petroleum Association of Canada. Day one focused on presentation of government and industry views on the criteria for three-lift, the rationale and field data in support of three- and two-lift procedures, and an examination of the various soil handling methods in use. During day two, five working groups discussed four issues: alternatives to three-lift; interim criteria and suggested revisions; research needs; definitions of terms. The results of the workshop are being used by a government/industry committee to revise soils handling criteria for pipelines.

71. **RRTAC 90-7: Reclamation of Disturbed Alpine Lands: A Literature Review. Hardy BBT Limited. 209 pp. $10.00**

This review covers current information from North American sources on measures needed to reclaim alpine disturbances. The review provides information on pertinent Acts and regulations with respect to development and environmental protection of alpine areas. It also discusses: alpine environmental conditions; current disturbances to alpine areas; reclamation planning; site and surface preparation; revegetation; and, fertilization. The report also provides a list of research and information needs for alpine reclamation in Alberta.

72. **RRTAC 90-8: Plains Hydrology and Reclamation Project: Summary Report. S.R. Moran, M.R. Trudell, T.M. Macyk and D.B. Cheel. 105 pp. $10.00**

This report summarizes a 10-year study on the interactions of groundwater, soils and geology as they affect successful reclamation of surface coal mines in the plains of Alberta. The report covers: Characterization of the Battle River and Wabamun study areas; Properties of reclaimed materials and landscapes; Impacts of mining and reclamation on post-mining land use; and, Implications for reclamation practice and regulation. This project has led to the publication of 18 RRTAC reports and 22 papers in conference proceedings and referred journals.

73. **RRTAC 90-9: Literature Review on the Disposal of Drilling Waste Solids. Monenco Consultants Limited. 83 pp. $5.00**

This report reviews the literature on, and government and industry experience with, burial of drilling waste solids in an Alberta context. The review covers current regulations in Alberta, other provinces, various states in the US and other countries. Definitions of various types of burial are provided, as well as brief summaries of other possible disposal methods. Environmental concerns with the various options are presented as well as limited information on costs and monitoring of burial sites. The main conclusion of the work is that burial is still a viable option for some waste types but that each site and waste type must be evaluated on its own merits.

74. **RRTAC 90-10: Potential Contamination of Shallow Aquifers by Surface Mining of Coal. M.R. Trudell, S.R. Moran and T.M. Macyk. 75 pp. $5.00**

This report presents the results of a field investigation of the movement of salinized groundwater from a mined and reclaimed coal mine near Forestburg into an adjacent unmined area. The movement is considered to be an unusual occurrence resulting from a combination of a hydraulic head that is higher in the mined area than in the adjacent coal aquifer, and the presence of a thin surficial sand aquifer adjacent to the mine. The high hydraulic head results from deep ponds in the reclaimed landscape that recharge the base of the spoil.

75. **RRTAC 91-1: Reclamation Research Annual Report - 1990. Reclamation Research Technical Advisory Committee. 69 pp. No longer available.**

This annual report describes the expenditure of $499 612 of Alberta Heritage Savings Trust Fund monies on research under the Land Reclamation Program. The report outlines the objectives and research strategies of the four program areas, and describes the projects funded under each program. The report lists the 70 research reports published under the program.

76. **RRTAC 91-2: Winter Soil Evaluation and Mapping for Regulated Pipelines. A.G. Twardy. 43 pp. ISBN 0-7732-0874-7. $5.00**

Where possible, summer soil evaluations are preferred for pipelines. However, when winter soil evaluations must be done, this report lays out the constraints and requirements for obtaining the best possible information. Specific recommendations include: restricting evaluations to the time of day with the best light conditions; use of core- or auger-equipped drill-trucks; increased frequency of site inspections and soil analyses; and, hiring a well-qualified pedologist. The province's soils are divided into four classes, based on their difficulty of evaluation in winter: slight (most soils); moderate; high; and, severe (salt-affected soils in the Brown and Dark Brown Soil Zones).

77. **RRTAC 91-3: A User Guide to Pit and Quarry Reclamation in Alberta. J.E. Green, T.D. Van Egmond, C. Wylie, I. Jones, L. Knapik and L.R. Paterson. 151 pp. ISBN 0-7732-0876-3. $10.00**

Sand and gravel pits or quarries are usually reclaimed to the original land use, especially if that was better quality agricultural or forested land. However, there are times when alternative land uses are possible. This report outlines some of the alternate land uses for reclaimed sand and gravel pits or quarries, including: agriculture, forestry, wildlife habitat, fish habitat, recreation, and residential and industrial use. The report provides a general introduction to the industry and to the reclamation process, and then outlines some of the factors to consider in selecting a land use and the methods for reclamation. The report is <u>not</u> a detailed guide to reclamation; it is intended to help an operator determine if a land use would be suitable and to guide him or her to other sources of information.

78. **RRTAC 91-4: Soil Physical Properties in Reclamation. M.A. Naeth, D.J. White, D.S. Chanasyk, T.M. Macyk, C.B. Powter and D.J. Thacker. 204 pp. ISBN 0-7732-0880-1. $10.00**

This report provides information from the literature and Alberta sources on a variety of soil physical properties that can be measured on reclaimed sites. Each property is explained, measurement methods, problems, level of accuracy and common soil values are presented, and methods of dealing with the property (prevention, alleviation) are discussed. The report also contains the results of a workshop held to discuss soil physical properties and the state-of-the-art in Alberta.

79. **RRTAC 92-1: Reclamation of Sterilant Affected Sites: A Review of the Issue in Alberta. M. Cotton and M.P. Sharma. 64 pp. ISBN 0-7732-0884-4. $5.00**

This report assesses the extent of sterilant use on oil and gas leases in Alberta, identifies some of the concerns related to reclamation of sterilant affected sites and the common methods for reclaiming these sites, and outlines the methods for sampling and analyzing soils from sterilant affected sites. The report also provides an outline of a research program to address issues raised by government and industry staff.

80. **RRTAC 92-2: Reclamation Research Annual Report - 1991. Reclamation Research Technical Advisory Committee. 55 pp. ISBN 0-7732-0888-7. $5.00.**

This report describes the expenditure of $485,065 of Alberta Heritage Savings Trust Fund monies on research under the Land Reclamation Program. The report outlines the objectives and research strategies of the five program areas, and describes the projects funded under each program. It also lists the 75 research reports that have been published to date.

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